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FINAL

National Petroleum Reserve-Alaska
Integrated Activity Plan
Environmental Impact Statement
Volume 4: Chapter 4 (Sections 4.8-4.13)

U.S. Department of the Interior
Bureau of Land Management

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Alaska

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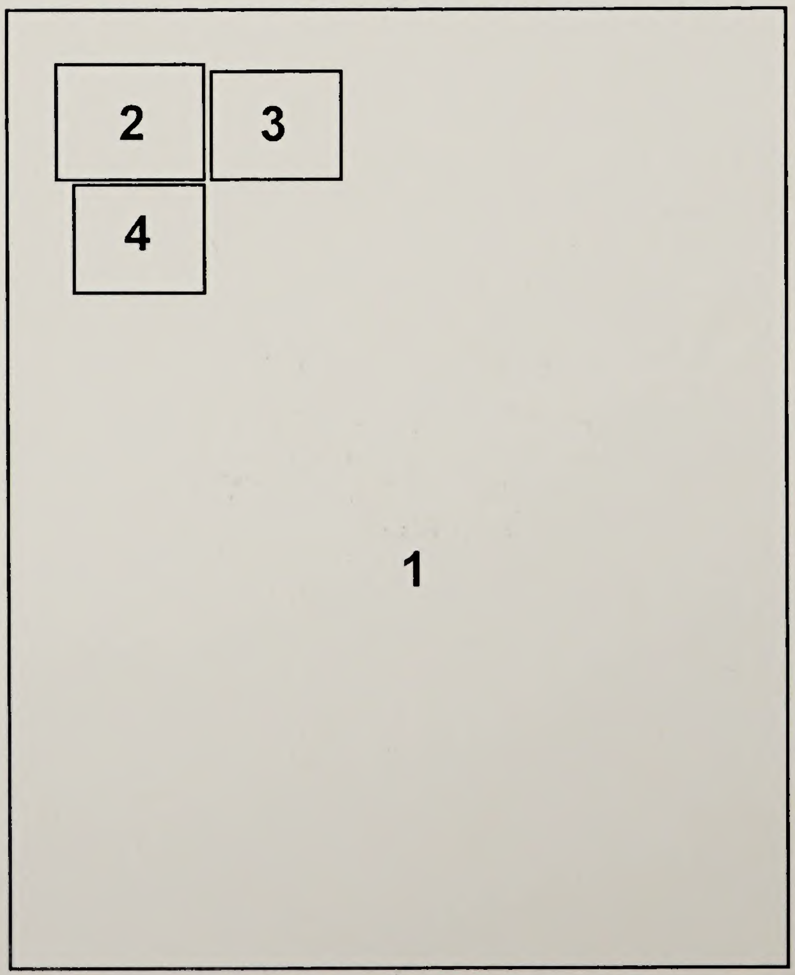

Cover Photos:

1. Along the Archimedes Ridge in the Utukok River Uplands of the National Petroleum Reserve-Alaska. © Patrick Endres
2. Winter petroleum exploration, National Petroleum Reserve-Alaska. Photo by NSSI
3. Polar Bear, North Slope, Alaska.
4. Two newly born caribou calves in the Utukok River Uplands of the National Petroleum Reserve-Alaska. © Patrick Endres

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National Petroleum Reserve-Alaska

FINAL

Integrated Activity Plan/ Environmental Impact Statement

Volume 4

Chapter 4 (sections 4.8 to 4.13)

Prepared by:

U.S. Department of the Interior
Bureau of Land Management
Anchorage, Alaska

In cooperation with:

North Slope Borough
U.S. Bureau of Ocean Energy Management
U.S. Fish and Wildlife Service

November 2012

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How the IAP/EIS is Organized

VOLUME 1

Chapter 1 – Introduction: Summarizes the purpose of and need for this IAP/EIS and decisions to be made.

Chapter 2 – Alternatives: Describes and compares proposed management alternatives.

Chapter 3 – Affected Environment: Presents existing natural and socioeconomic resources in the NPR-A and trends, including those associated with climate change.

VOLUME 2

Chapter 4 – Environmental Consequences (sections 4.1 – 4.4): Provides the assumptions upon which the impact analysis rests and evaluates impacts of Alternatives A and B-1 on resources and uses in the NPR-A relevant to making a decision among the alternatives.

VOLUME 3

Chapter 4 – Environmental Consequences continued (sections 4.5 – 4.7): Evaluates impacts of Alternatives B-2 (preferred alternative), C, and D on resources and uses in the NPR-A relevant to making a decision among the alternatives.

VOLUME 4

Chapter 4 – Environmental Consequences continued (sections 4.8 – 4.13): Evaluates the cumulative impacts on resources and uses in the NPR-A and other effects relevant to making a decision among the alternatives.

VOLUME 5

Chapter 5 – Consultation and Coordination: Describes public and government (including tribal) consultation undertaken for this plan and the development of alternatives and lists the plan's preparers.

Chapter 6 – Comments and Responses: Presents public comments on the Draft IAP/EIS and responses to the comments.

VOLUME 6

Appendix A: ANILCA Section 810 Analysis of Subsistence Impacts

Appendix B: Federal, State, and Local Permits and/or Approvals for Oil and Gas Exploration, Development, and Production Activities

Appendix C: NPR-A Climate Change Analysis: An Assessment of Climate Change Variables in the National Petroleum Reserve in Alaska

Appendix D: Essential Fish Habitat

Appendix E: Common, Scientific and Iñupiaq Names of Species Listed in the IAP/EIS

Appendix F: BLM Sensitive Species List for Alaska

Appendix G: Information, Models, and the Assumptions Used to Analyze the Effects of Oil Spills

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Section 4.8:

Cumulative Effects

CHAPTER 4: Environmental Consequences (Continued)

4.8 Cumulative Effects

The National Environmental Policy Act and its implementing regulations require an assessment of the proposed action and other actions that have occurred in the past, are occurring in the present, or are likely to occur in the future, which together may have cumulative impacts that go beyond the impacts of the proposed action itself. As defined by 40 C.F.R. § 1508.7:

> "Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

The purpose of this cumulative effects analysis is to determine if the effects of the actions considered in this plan, together with other past, present, and reasonably foreseeable future actions on the North Slope and elsewhere, have the potential to interact or accumulate over time and space, either through repetition or combined with other effects, and under what circumstances and to what degree they might accumulate.

4.8.1 Structure of the Cumulative Impacts Analysis

For this plan, the analysis of cumulative impacts follows guidance provided in "Considering Cumulative Effects Under the National Environmental Policy Act" (CEQ 1997). The plan will identify and describe actions—past, present, and future—that may impact the elements of the environment, including people, that may be impacted by the plan's decisions. These include not only the actions that may follow from the decisions in this plan, but also actions undertaken by others within and outside the planning area. The plan also provides the geographic and temporal scope of the analysis and addresses additive, synergistic, and countervailing impacts among the cumulative impacts.

4.8.1.1 Class of Actions Whose Effects are to be Analyzed

Both non-oil and gas activities and oil and gas activities are considered in the analysis. The impacts from these activities are considered in the context of a changing environment, including climate change. The assumptions and scenarios used by the resource specialists in the analyses of the cumulative impacts include those identified for the planning area in section 4.2 (Volume 2), "Introduction and Basic Assumptions for the Environmental Consequences Assessment."

Non-Oil and Gas Activities

Non-oil and gas activities include those activities that have occurred in the past, are presently occurring, or are likely to occur in the future. These include the types of activities discussed in section 4.2.1.1 (Volume 2), "Activities Not Associated with Oil and Gas

Exploration and Development," that could occur within and outside of the NPR-A, and other North Slope activities, including resettlement and expansion of Native villages, and other residential, commercial, and industrial development on the North Slope, and military (Distant Early Warning-Line) and other government sites.

Oil and Gas Activities

Oil and gas activities include those direct and indirect activities that have occurred in the past, are presently occurring, or are likely to occur in the future. These include the types of activities discussed in section 4.2.1.2 (Volume 2) that could occur within the planning area and on the North Slope. The activities likely to have the greatest effects vary by resource. For example, oil and gas activities considered in greatest detail in the cumulative impacts analysis for biological resources and subsistence users are:

- Exploration activities, including seismic activities, off-road travel, and exploration drilling
- Road construction (ice, peat, and gravel roads)
- Industrial activity (oil field development and production and related infrastructure)
- Oil spills
- Marine-related activities
- Site reclamation

In contrast, employment and income are important activities to consider when evaluating the economy. Activities analyzed for each resource are identified in section 4.8.7.

4.8.1.2 Appropriate Cumulative Impact Temporal and Spatial Domain

Temporal Domain

The analysis period covered by the cumulative effects analysis begins in approximately 1900, when first exploration on the North Slope began, and continues through about 2100. The ending date is based on the assumption that oil and gas fields will be discovered and developed in the planning area over approximately the remainder of the first half of this century and that production and abandonment activities could last for approximately 50 more years.

Developments for which no solid proposal has been submitted or which seem unlikely to occur within the foreseeable future are considered speculative. Speculative developments are not considered reasonably foreseeable and are not analyzed as part of the cumulative impacts associated with this IAP/EIS.

Spatial Domain

The spatial domain considered in this cumulative analysis extends across much of the North Slope. It includes the contiguous State and Native lands to the east of the NPR-A that have potential cumulative relationships with resources and peoples in the NPR-A. For example nearby oil and gas infrastructure conceivably could impact air quality within the NPR-A; Colville River aquatic habitat important for some fish in the NPR-A could be affected by activities in the drainages of rivers that flow into the Colville from the east; some members of the Teshekpuk and Western Arctic caribou herds cross to the east side of the Colville River and members of Central Arctic caribou herd sometimes enter a short distance into the NPR-A near Nuiqsut; and subsistence hunters and trappers sometimes use lands east of the Colville River, in some cases to approximately the Dalton Highway area. On the west, the spatial domain extends to encompass all lands north of the Brooks Range and the Lisburne Peninsula. The NPR-A's western boundary follows a line of longitude. Animals, including the Western Arctic Herd, pass freely across boundary; several rivers, including the Utukok, pass across the boundary; and subsistence users from Wainwright utilize substantial parts of the North Slope west of the NPR-A. Activities in waters offshore from the NPR-A may also impact species that use the NPR-A, particularly its bays and lagoons. Finally, this plan also considers cumulative effects to resources, primarily effects to migratory birds and mammals, that could occur farther afield, from relatively nearby, such as a proposed road to the Ambler mining district, to far away outside of Alaska.

4.8.1.3 Magnitude of Effects and Whether Those Effects are Accumulating

The potential extent of the total cumulative effects (e.g., number of animals and habitat affected, jobs and revenues created or lost), and how long the effects might last (e.g., population recovery time, duration of income flows) are estimated to determine the magnitude of effects that could accumulate for each resource. Where possible, the assessment of effects on a resource is based on quantitative analysis (e.g., number of miles of gravel roads constructed; number of animals killed). However, many effects are difficult to quantify (e.g., animal behaviors; human perceptions) and a qualitative assessment of effects is made.

As suggested by the CEQ (1997) handbook, Considering Cumulative Effects Under the National Environmental Policy Act, this IAP/EIS considers the following basic types of cumulative effects that might occur:

- "additive" (loss of sensitive resources from more than one incident),
- "countervailing" (an effect of an action is at least partially offset by the effect of another action; for example, one action could promote a certain type of habitat while another could reduce it), and
- "synergistic" (total effect is greater than the sum of the effects taken independently).

Additive effects on specific resources often are difficult to detect and do not necessarily add up in the strict sense of one plus one equals two. It is much more likely that an additive effect would be greater than one but less than two. A synergistic effect, in theory, is a total effect that is greater than the sum of the additive effects on a resource. To arrive at a synergistic effect in this example (continuing with the numeric analogy), the total cumulative effect would need to end up greater than two. In the highly variable Arctic environment, where natural variations in population levels can exceed the impacts of human activity, such an effect would need to be much greater than the hypothetical two to be either measurable or noteworthy.

In the analyses that follows, effects should be considered to be additive in nature, unless otherwise noted. While synergistic impacts have been demonstrated in the laboratory (for certain types of chemical reactions, for example), there is almost no evidence of such impacts occurring when dealing with biological resources in the Arctic environment. Where synergistic impacts are not specifically accounted for in the analysis section, it is because there are neither studies nor information supporting the identification of such impacts. Resource analysts have striven to keep the cumulative analysis useful, manageable, and concentrated on meaningful potential effects. The cumulative analysis considers in greatest detail activities that are more certain to happen and that are geographically in or near the NPR-A.

4.8.2 Activities Not Associated with Oil and Gas Exploration and Development Considered in the Cumulative Effects Analysis

This section describes past, present, and reasonably foreseeable non-oil and gas activities that may contribute to cumulative effects. Non-oil and gas actions include continued human activities such as sport and subsistence hunting and fishing, tourism, and recreational activities. Other non-oil and gas activities that could occur on the North Slope include growth and development associated with villages and military sites.

4.8.2.1 North Slope Development

There are six North Slope villages within the geographic range (also referred to as geographic scope or spatial domain for the cumulative effects analysis) being considered for this cumulative effects analysis: Point Lay, Wainwright, Atqasuk, Barrow, Nuiqsut, and Anaktuvuk Pass. While a number of these locations were occupied at various times throughout the human history on the North Slope, much of the occupation prior to 1900 consisted of seasonal dwellings. These villages have been established or reestablished since 1900, and the establishment and subsequent growth represent cumulative impact to the North Slope environment. Villages consist of dwellings and other buildings, sewage and water systems, gravel roads, gravel airstrips/airports, and other structures. Their establishment, current area, and population statistics are described in Table 4-33 and Table 4-34. [1]

Table 4-33. Physical size of the North Slope villages considered in the cumulative effects analysis

Village	City limits (acres)	Tracts (acres)
Anaktuvuk Pass	3,302	373
Nuiqsut	5,760	649
Atqasuk	27,353	328
Barrow	13,866	3,028
Wainwright	9,222	1,022
Point Lay	Not Incorporated	1,576
Total	60,123	7,128

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[1] Most information in this section is available from the State of Alaska Labor and Workforce Development website http://live.laborstats.alaska.gov/cen/dparea.cfm and from the website of the North Slope Borough at http://www.north-slope.org/. Both websites were accessed on August 30, 2011.

Table 4-34. Population of North Slope villages within the cumulative effects analysis area

Village	1950	1973	1980	1988	1990	1993	1998	2003	2010
Anaktuvuk Pass	66	134	203	264	259	270	314	329	324
Nuiqsut	NA	128	208	314	354	418	420	416	402
Atqasuk	49	NA	107	219	216	237	224	250	233
Barrow	951	2,167	2,267	3,335	3,469	3,908	4,641	4,429	4,212
Wainwright	227	353	405	514	492	584	649	556	556
Point Lay	75	31	68	132	139	192	246	260	189
Total	1,414	2,957	3,423	5,005	5,153	5,839	6,750	6,524	6,155

NA = not available

The village of Point Lay has not been incorporated under State law as a municipality, but has been incorporated as a Native Village under the Indian Reorganization Act by the Bureau of Indian Affairs. Since the early 1970s, the village's population grew from less than a few dozen residents to 260 in 2003. The current census lists 189 residents, and 89 percent are Iñupiat. Point Lay has gravel roads and an airstrip, cultural center, school, health clinic, police and fire stations, and a local store. The North Slope Borough provides public electricity. The borough provided water and sewer project to the village in the early 2000s. Transportation to the village is provided by scheduled airline and charter service at the local airport.

Wainwright was established in 1904 when the Alaska Native Service built a school there. The community was incorporated as a second-class city in 1962. Wainwright has been one of the larger villages in the borough, and it grew from 353 residents in 1973 to 556 in 2010. The village has gravel roads and an airstrip, cultural center, school, health clinic, police and fire stations, and a local store. The North Slope Borough provides all utilities. Transportation to the village is provided by scheduled airline and charter service at the local airport.

The Village of Atqasuk is at a site that has historically been the location of dwellings. Coal was mined in the community, then known as Meade River, in World War II and freighted to Barrow. The population dwindled in the 1960s but the village was reestablished in the 1970s under the name Atqasuk, and incorporated as a second-class city in 1982. Atqasuk has had a fairly consistent population since the late 1980s and in 2010 counted 233 residents, 93 percent of whom were Iñupiat Eskimos. The village has a public electric system, a school, police and fire stations, airstrip, health clinic, and a local store. About 85 percent of households have water piped to their house. Transportation to the village is provided by scheduled airline and charter service at the local airport.

Barrow is the economic, transportation, and administrative center for the North Slope Borough and the largest community, with a population in 2003 of 4,429 and 4,212 in 2010. The city was incorporated as a first class city in 1959. Most Barrow homes are heated by natural gas from nearby gas fields. Utilities are available through Barrow Utilities and Electric Cooperative. The community has schools including a community college, stores, hotels, police and fire stations, and a bank. Transportation to and from Barrow is provided by the Wiley Post – Will Rogers Regional Airport, including jet service.

Nuiqsut was established in 1974 when 27 families moved to the present location. The new residents lived in a tent city for 18 months before permanent housing could be built. The village was incorporated as a second-class city in 1975. In 2010, there were 402 residents in the village; about 90 percent were Iñupiat. The village has a school, health clinic, store, police and fire station, a public transportation system, and a local store. All but one of the Nuiqsut households had running water by 2003. The village has a public utility (electricity) system. Gas from CPAI's Alpine facility has powered the generators for the local power system since 2008. Transportation to the village is provided by scheduled airline and charter service at the local airport.

The Village of Anaktuvuk Pass was settled in the 1940s. The inland Nunamiut Eskimos were nomadic and largely vacated the Brooks Range area in the early 1900s due to a collapse in the caribou populations. By the 1940s, several Nunamiut families returned to the area and settled at the present village site. The community was incorporated as a second-class city in 1957. The village population has grown steadily from the 1970s and has been stable this past decade with 324 residents in 2010. Approximately 92 percent of the population in 2010 was of Iñupiat descent. The village has a school and health clinic. In 2003, approximately 90 percent of the households had running water, up from only a quarter of the population in the late 1990s. Flush toilets have also reached 90 percent of the households thanks to recent completion of a water and sewer project by the North Slope Borough. Transportation to the village is provided by scheduled airline and charter service at the local airport.

Projecting population growth is fraught with problems, particularly projections as far as the end of this century when we project that oil and gas production from the planning area will be reaching its end. The period from 1988 to 2003 represents a period of gradual expansion of oil and gas development. This development, primarily through tax revenues to the North Slope Borough and profits to local corporations, helped support a roughly corresponding growth of populations in North Slope Borough communities. The North Slope population decreased by about 8.8 percent between 1998 and 2010. For analysis purposes, however, we assume that population would fluctuate but over time reflect oil and gas production. If oil and gas production remains at current levels, the North Slope population will likely remain stable or decline. If onshore and offshore oil and gas production in the North Slope increases as predicted by Thomas et al. (2009) then the population would probably increase at approximately the 2 percent annual rate observed between 1988 and 2003.

Oil and gas production from the North Slope (including the NPR-A, offshore drilling, and onshore drilling in other areas) may peak during the middle part of this century (Thomas et al. 2009). Depending on the amount of North Slope production that occurs during the middle and later parts of this century, long-term population growth could continue through mid-century and then stabilize or decline.

Also, this analysis assumes that any growth in the population of communities will translate to approximately the same amount of growth in the land within communities that are developed for housing, commercial and government structures, and other community infrastructure. Based upon review of aerial photographs and consultation with the North Slope Borough, the BLM estimates that approximately 1,800 acres had been occupied to date from community development by 2008. Assuming community infrastructure and footprint growth at roughly the same pace as population (with most growth between 2020 and 2050) the communities' footprint would double to approximately 3,600 acres by the time population may level off in mid-21st century. This excludes projects such as the road from the Dalton Highway to Umiat. (The State of Alaska is proposing to develop a road between the Dalton Highway and Umiat in the southeastern NPR-A. The road may be open to the public, but the purpose and primary use of the road may be for oil and gas development. See the section called "Road and Pipeline between Umiat Area and Dalton Highway" on page 31 for a discussion of the proposed road.)

4.8.2.2 Military Development and Former Distant Early Warning-Line Stations

Military development in the region includes staging/storage areas for military exercises, staging and operational sites associated with the Naval Arctic Research Laboratory, and miscellaneous drummed fuel caches. Many military sites have not been documented and continue to be discovered. Naval Arctic Research Laboratory sites within the NPR-A include operational sites on the northwest shore of Teshekpuk Lake and two locations south of the Colville River, one on No Luck Lake and the other at a location called Brady. Exercise sites include the Umiat airfield, utilized for a brief period in the 1950s by the U.S. Air Force. Portions of the Naval Arctic Research Laboratory withdrawal still remain near Barrow and have been undergoing removal and remedial actions since the 1990s. The most significant military developments are the Distant Early Warning (DEW) and Northern Warning System Sites. The Coast Guard also had towers that have been removed at Skull Cliff (east of Peard Bay), Barter Island, and Barrow.

The Distant Early Warning-Line was an integrated chain of radar and communications sites stretching across Alaska, Northern Canada, and Greenland. The DEW-Line was initiated in 1954 when President Eisenhower signed a bill approving construction (CEMML 2006). Its purpose was to detect any incoming, over-the-pole, aircraft invasions emanating from the Soviet Union. Actual construction took place between 1954 and 1957 and the system was declared operational on July 31, 1957. A total of 63 radar sites were constructed, 13 west of the Canning River along the Chukchi and Beaufort Seas in Alaska, six of which are on BLM-managed lands within the NPR-A.

Each Distant Early Warning -Line site consisted of a gravel runway and road system, permanent housing, water and fuel storage tanks with pads, heating plants, and (petroleum/oil/lubricant [POL], sewage, and water) pipelines, garages, towers, and antennae. Military and civilian airlifts, sealifts during the summer, and cat trains distributed the materials to construct the permanent facilities. Land within the 13 sites varied from 150 to 2,835 acres. There were three general types of stations, main stations, auxiliary stations, and intermediate stations (Table 4-35). Main stations were larger and had more facilities and larger staff. Gravel runways were at least 5,000 feet long and 142 feet wide at main stations, 3,000 feet long at auxiliary stations, and 1,000 feet long at intermediate stations. During operation, auxiliary sites had staffs of about 25-40 persons each, but main stations had 225 to 250 employees. Intermediate stations, which operated between 1957 and 1963, had a staff of five or fewer.

Table 4-35. Distant Early Warning-Line and radar sites constructed on the North Slope of Alaska

Site name	Site number[1]	Size (acres)	Status
Cape Lisburne	LIZ-1[2]	1.125	Active long range radar site
Cape Sabine	LIZ-A (int)	431	Abandoned, structures removed
Point Lay	LIZ-2 (aux)	2,835	Abandoned, structures, etc. remain
Icy Cape	LIZ-B (int)	218	Abandoned, structures removed
Wainwright	LIZ-3 (aux)	1,191	Abandoned, structures removed beginning in 2011
Peard Bay	LIZ-C (int)	1,460	Abandoned, structures removed
Point Barrow	POW-Main	268	Active, some structures removed 2011
Cape Simpson	POW-A (int)	not determined	Abandoned, North Slope Borough property
Point Lonely	POW-1 (aux)	2,830	Abandoned, one structure removed 2009
Kogru	POW-B (int)	150	Abandoned, structures removed
Oliktok	POW-2 (aux)	2,325	Active
Point McIntyre	POW-C (int)	not determined	Abandoned, structures removed; landfill relocation planned
Bullen Point	POW-3 (aux)	620	Abandoned, DEW-era buildings removed

1. Main = Main station; aux = auxiliary station; and int = intermediate station.

2. LIZ-1 was an early site Aircraft Control and Warning Station and does not match the description of a main, auxiliary, or intermediate station.

The table includes North Slope sites west of the Canning River. Collision Point (POW-D), Demarcation Bay (BAR-A), and Barter Island are not included in this analysis because these sites are outside of the cumulative geographic range; i.e., east of the Canning River (see section 4.8.1.2, for a definition of cumulative geographic range).

Sources: Lackenbauer et al. 2005, CEMML 2006.

The intermediate Distant Early Warning-Line sites operated only between 1957 and 1963. The remaining stations continued to operate until 1989. Alternating stations along the coastline then were converted as part of the Northern Warning System to long-range radar and short-range radar sites, respectively. The long-range radar stations were in operation by 1990, followed by the short-range radar stations in 1994.

In subsequent years, all the Alaskan sites except the long-range radar stations at Point Barrow, Oliktok, and Barter Island were abandoned. Wastes and contaminated soils consisting of petroleum, lubricants, oils, heavy metals, and polychlorinated biphenyls (PCBs), along with considerable volumes of debris and general refuse are associated with all of the abandoned sites. Investigations were initiated in the early 1980s at these sites. Removal and remedial actions began in the 1990s at most of the sites. Focused investigations continue on a case-by-case basis, and planning is commencing for continued removal action at selected sites.

An airstrip and facilities at Cape Lisburne were constructed in the early 1950s. It was active until 1983 when it was converted to a long-range radar site. Remediation work of the facilities was conducted through 2005. The Cape Lisburne Long Range Radar Site is still active. A landfill remains, and remnants of other infrastructure will require additional remediation (U.S. Air Force 2010).

Cape Sabine was designed as a Distant Early Warning-Line intermediate radar site and was in use from the 1957 to 1963. It included a 2,700 feet runway, approximately 1 mile of roads, and radar facilities. The radar facilities were dismantled by 2000 and remediation work has occurred.

The Point Lay auxiliary Distant Early Warning-Line was constructed during the mid-1950s; in the 1980s the Distant Early Warning-Line radar was replaced by FPS-117 Minimally Attended Radar (MAR) and became Point Lay Long Range Radar Site which was deactivated in 2000 (CEMML 2006). The Point Lay Long Range Radar Site has undergone a series of activities to remove former infrastructure, debris, and contaminants (e.g., Operation Clean Sweep, USAF 2006). Future activities planned include cleanup of the deactivated landfill.

Initial removal actions at the Icy Cape Intermediate Distant Early Warning-Line site were conducted in 1997 and included all buildings, two 20,000-gallon and six 300-gallon oil storage tanks, 800 feet of petroleum/oil/lubricant pipeline, a fuel pumping station, more than forty 55-gallon petroleum/oil/lubricant drums, a 240-feet unmarked tower, and 1,500 cubic yards of contaminated gravels. Soil sampling for potential PCB-contamination was conducted on the site in 2003. Future planned restoration activities include monitoring of the three remaining landfills and soil sampling of stained soils.

Initial removal actions were initiated at the Wainwright Distant Early Warning-Line Station with the demolition of the approximately 3-mile long petroleum pipeline connecting the former Wainwright Short Range Radar Site with fuel tanks located next to the Chukchi Sea just north of the village of Wainwright. The crushed pipeline materials remain stockpiled at the main station. The above water portions of a partially submerged beach landfill (identified as LF006) were removed in 2010. Building demolition and debris removal activities were initiated in 2011 and are ongoing. Removal of an upgradient landfill established in 1986 (identified as LF005) is planned for 2012/2013.

Initial removals at the Peard Bay Intermediate Distant Early Warning-Line site were conducted in 1997 and included all buildings, a fuel pumping station, a 240-feet unmarked tower, and approximately 1,000 cubic yards of contaminated gravel fill on 5 acres. Soil sampling for additional petroleum-contamination and potential PCB-contamination was conducted on the site in 2003. One or more landfills remain at the site.

The Distant Early Warning-Line Station at Point Barrow was replaced by FPS-117 Minimally Attended Radar (MAR) and converted to a Long Range Radar Site (CEMML 2006). Point Barrow remains an active facility, yet has three Installation Restoration Program Sites, which have been scheduled for environmental restoration. In 2011, removal of contaminated soils, unused towers, pipelines, fuel tanks, and powerlines were conducted at Point Barrow. The Point Barrow facility currently has a long-term use authorization from the Bureau of Land Management.

Removal actions at the Cape Simpson Intermediate Distant Early Warning-Line site, which was transferred to the North Slope Borough in the early 1980s, were conducted in 1998. All structures were demolished and four 20,000-gallon and eight 300-gallon fuel storage tanks, two 1,000-gallon propane tanks, a fuel pumping station, 25 batteries, a 240-feet unmarked tower were removed, as well as petroleum/oil/lubricant-contaminated soil, a contaminated landfill, and petroleum/oil/lubricant-contaminated surface water.

The Point Lonely site received a 20-year use authorization from the Bureau of Land Management in 1986. The site remained active until 2007. Abandonment planning is proceeding for the site. Based upon historical usage and prior sampling events, 10 environmentally impacted micro-sites have been identified as Areas of Concern. Major concerns are petroleum/oil/lubricants, PCBs, two landfills, and polycyclic aromatic hydrocarbons. Building, tower, tanks and pipeline demolition, and removals or remediation of landfills or contaminated soils at Point Lonely has been ongoing since 2009.

Initial removals at the Kogru Intermediate Distant Early Warning-line site were conducted from 1996 to 1999, and included all buildings, eight 300-gallon oil storage tanks, and more than sixty 55-gallon petroleum/oil/lubricant drums. Additional soil sampling was conducted in the field to verify there is no petroleum or PCB contamination. One eroding landfill cell removal at Kogru occurred in the winter 2009. Monitoring of the remaining landfill cells is ongoing.

East of the NPR-A, the Oliktok site remains active. Seven environmentally impacted areas have been identified at the Oliktok Distant Early Warning-Line Station. Removal operations were conducted in 2007-2008. Environmental concerns that have been identified at these areas are petroleum/oil/lubricant, PCB, general refuse, and insecticides.

East of the Deadhorse area is Bullen Point. Five environmental areas of concern, within the former Bullen Point (aka Flaxman Island) Distant Early Warning-Line station (POW-3) have been identified with possible petroleum/oil/lubricant, PCB, and general refuse contamination. The Air Force Project Clean Sweep involved major building demolition and debris removal activities at these sites in 2008-2009.

4.8.3 Oil and Gas Exploration and Development Activities Considered in the Cumulative Effects Analysis

This section discusses the history and describes a scenario of future of development in the region by identifying past, ongoing, and reasonably foreseeable oil and gas activities in the NPR-A and elsewhere in the geographic scope of this analysis. Oil development has been the main agent of industrial change on the North Slope in the twentieth and twenty-first centuries. Oil and gas exploration activities have occurred on the North Slope since the early 1900s and oil production has occurred for 35 years. Gas production from the Barrow gas fields, subsidized by the federal government, began over 60 years ago. Associated industrial development has included the creation of an industry support community airfields at Deadhorse and Kuparuk and an interconnected industrial infrastructure that includes roadways, pipelines, production, and processing facilities, gravel mines, and docks. In 1977, the Trans-Alaska Pipeline System began to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska. Today, it continues to transport the North Slope's entire production, and it is projected to do so for many years into the future.

For this analysis, oil scenarios were developed based on estimates of economically recoverable oil and gas potential and the activities associated with exploration, development, and production. The scenarios are conceptual views of the future that include the timing and extent of future petroleum activities within the temporal and spatial domains. Estimates of anticipated production consider many factors, including the recoverable resources of the area at projected future prices, past industry leasing and exploration efforts, and future economic and regulatory conditions.

This cumulative impact analysis analyzes impacts of actions in the following categories:

- **Past and Present Exploration and Development:** Exploration, development, and production activities and associated infrastructure for existing oil operations and those undergoing agency approval processes. This category involves ongoing maintenance and near-term construction of present infrastructure, including support facilities and transportation systems.
- **Reasonably Foreseeable Future Exploration and Development:** Future exploration, development, and production activities, including support and transportation components, that would be associated with extraction of discovered oil and gas or discovery and extraction of undiscovered oil and gas in areas with existing oil leases or for which land managers are planning to hold lease sales.

4.8.3.1 Past and Present Exploration and Development

The North Slope of Alaska is a very sparsely populated region of extreme climate, with abundant energy and other natural resources. Exploration and industrial development for extraction of the mineral resources of the region (principally oil and gas), which has been active over the past 90 years, is the primary man-induced change to the North Slope (Table 4-36).

The most intense development activity to date occurred during the 1970s and early 1980s. It was during this period that the Prudhoe Bay and Kuparuk oil fields were developed, Trans-Alaska Pipeline System and the haul road (Dalton Highway) were constructed, and a large portion of the roads, drilling pads, gravel sources, collector pipelines, and production facilities were built. It was also a period of much activity in the NPR-A, with thousands of miles of seismic lines surveyed and dozens of exploratory wells drilled. Since then, additional North Slope development has occurred, but incremental physical disturbance to the environment has been reduced.

Table 4-36. Oil exploration and development on the North Slope

Date	Event
Before recorded history	Visible oil seepages used by Native inhabitants of the North Slope.
1882	U.S. government representatives hear of oil seepages while traveling in the area.
1886	First non-Natives see seepages at Cape Simpson.
1901	Peters and Schrader traverse the Brooks Range and North Slope recording the geology and geography of the region.
1906-1914	E. Leffingwell mapped the Arctic Coast east of Barrow.
1909	First description of Cape Simpson deposits published.
1914	First oil-related claim staked.
1921	Additional claims staked by individuals and industry.
1921	Large deposits of oil discovered in Oklahoma and Texas and industry loses interest in the remote Arctic.

Table 4-36. Oil exploration and development on the North Slope

Date	Event
1922	First industry-sponsored geological investigation of North Slope oil potential.
1923	Naval Petroleum Reserve No. 4 (PET-4) established.
1923-1926	First U.S. Geological Survey analysis of PET-4 potential.
1943	Territory of Alaska Bureau of Mines sends field party to the North Slope to investigate oil and gas seepages.
1944	Start of PET-4 petroleum exploration program; PET-4 headquarters established at Barrow; land north of the drainage divide of the Brooks Range withdrawn from public entry by the Secretary of the Interior; and Public Land Order 82.
1945	Thirty-one shallow core tests drilled at Cape Simpson and oil was produced in flow tests.
1945-1952	Numerous geophysical studies conducted across PET-4 find oil and gas.
1947	Office of Naval Research establishes Arctic Research Laboratory.
1949	High sulfur, heavy oil found at a test well drilled near Fish Creek, and gas discovered near Barrow.
1953-1968	Federal geologic field studies continue in PET-4 and several major oil companies begin exploration.
1957	Oil discovered in Cook Inlet (south-central Alaska).
1958	Public Land Order 82 modified; Federal leasing begins on the North Slope; first industry-sponsored geological field programs; and Alaska Statehood Act passed.
1959	Alaska becomes the 49th state in the Union.
1962	First industry-sponsored seismic program.
1963-1967	First industry exploration well drilled on the North Slope; 11 unsuccessful wells drilled and industry interest in the North Slope wanes.
1964	First State of Alaska lease sale on the North Slope.
1965	Area that eventually includes Prudhoe Bay leased.
1967	Initial exploratory drilling at sites that would become Prudhoe Bay field.
1968	ARCO announces the discovery of Prudhoe Bay oil field, the largest in North America.
1969	Kuparuk, West Sak, and Milne Point fields discovered; Alaska State Lease Sale No. 23 held; and Federal lease sales suspended on the North Slope for the next 10 years because the Secretary of the Interior imposed freezes due to Native claims.
1970	National Environmental Policy Act signed into law.
1971	Alaska Native Claims Settlement Act passed.
1974-1976	Federally-sponsored exploration along the Barrow Arch.
1976	PET-4 transferred from the Navy to the Department of the Interior and renamed the National Petroleum Reserve in Alaska; major exploration effort launched by the USGS in the NPR-A.
1977	Trans-Alaska Pipeline System operational.
1979	Initial leasing of portions of the state and Federal OCS waters of the Beaufort Sea.
1980	Alaska National Interests Land Conservation Act passed.
1981	First OCS exploration well drilled.
1982	Initial leasing of portions of the NPR-A.
1985	First industry exploration well drilled in the NPR-A.
Various times	Initial leasing of portions of Arctic Slope Regional Corporation lands.
Early 1990s	Last of the NPR-A leases from the initial leasing program are relinquished.

Table 4-36. Oil exploration and development on the North Slope

Date	Event
1994	Discovery of the Alpine field.
1998	Northeast NPR-A IAP/EIS Record of Decision signed.
1999	Lease sale held in Northeast NPR-A.
2000	Alpine production begins.
2001	Northstar field begins production; development of Liberty field suspended; Phillips (successor of ARCO) announces discoveries in NPR-A.
2002	Lease sale held in Northeast National Petroleum Reserve-Alaska.
2003	Beaufort Sea Sale 186 held.
2004	Northwest NPR-A IAP/EIS Record of Decision signed.
2004	Lease sale held in Northwest NPR-A.
2004	Alpine Satellite Development Plan EIS Record of Decision signed.
2005	Beaufort Sea Sale 195 held.
2006	Northeast NPR-A Amended Record of Decision signed.
2006	Startup of the Alpine satellite oil production pad known as Fiord or CD-3.
2006	Lease sale held in Northwest NPR-A.
2006	Beaufort Sea Sale 202 proposed.
2006	Startup of the Alpine satellite oil production pad known as Nanuq or CD-4.
2007	MMS Chukchi Sea Planning Area O&G Lease Sale 193 Final EIS released.
2008	MMS Chukchi Sea Lease Sale 193 yields nearly $2.7 billion in winning bids.
2008	Northeast NPR-A Supplemental Record of Decision signed.
2008	Lease sale held in Northeast NPR-A.
2010	U.S. Corps of Engineers denies ConocoPhillips' CD-5 application
2010	Lease sale held in Northeast NPR-A.
2011	Lease sale held in Northeast and Northwest NPR-A
2011	State conducts North Slope lease sale

More recent fields have generally been developed in areas adjacent to existing producing areas, reducing the amount of additional support infrastructure (roads, pipelines, and processing facilities) needed to support additional production. At the same time, changes and improvements in technology have generally decreased the physical disturbance caused by more recent exploration, development, and production activities.

The following sections discuss the history of exploration and development on the North Slope and nearby marine waters. Much of this summary is derived from NRC (2003) and in Gryc (1988).

Before 1900

Oil seepages that are seen today along the Arctic Coast, from Skull Cliff on the Chukchi Sea to Brownlow Point on the Beaufort Sea, were the first evidence of potentially significant petroleum deposits on the North Slope of Alaska. Especially important were the active ponds of oil and layers of tar at Cape Simpson, just east of Barrow, likely known to the Native inhabitants long before recorded history. In 1881-1883, John Murdoch, a member of the U.S. Navy's International Polar Expedition, visited Point Barrow and vicinity, and in 1892 reported that the expedition heard stories of a lake of tar on an island a one-day sail east of Point Barrow, most likely Cape Simpson (Murdoch 1892). In August of 1886, the first non-Native people to see the Cape Simpson seepages could have been Charles Brower and his partner Patrick Grey while on a hunting trip (Brower 1942). The North Slope's potential as a significant oil province was further shown when Ensign W. L. Howard found a pebble-sized piece of oil shale along the Etivluk River in 1886 (Smith and Mertie 1930).

1900 to 1940

In 1904, W. Peters and F. Schrader, a topographer and a geologist, published the first recorded systematic geologic and geographic traverse of the Brooks Range and the North Slope (Schrader and Peters 1904). In 1901, the researchers traveled by way of the John, Anaktuvuk, and the Colville rivers, naming and describing the Lisburne Formation of the Mississippian age and the Cretaceous rocks in the area. They noted the anticlinal structures in the foothills of the Brooks Range and numerous coal seams along the Colville and Anaktuvuk rivers. They also described the coal exposures along the northwest coast, which were mined by Alaska natives and whalers for many years.

From 1906 to 1914, E. Leffingwell mapped the Arctic Coast (Leffingwell 1919). He described and named the rock formations that were later discovered as the oil-bearing rocks at Prudhoe Bay and noted the seepages at Cape Simpson. He concluded that, "Even if an oil pool were found in the northern region, there is serious doubt of its availability under present conditions, though it might be regarded as a part of the ultimate oil reserves that would sometime be developed."

From 1909 to 1921, individuals and industry representatives staked claims, under the extant mining laws, at Cape Simpson, Peard Bay, and along the Meade, Kukpowruk, and Kokolik rivers. During that time, large deposits of oil were discovered in Oklahoma and Texas and industry shifted their interest to those new places of production rather than the North Slope (Van Valin 1941).

About 1920, the U.S. Navy began to convert their engines from coal to oil, and an oil shortage was being predicted. In 1923, in order to provide for the increased oil needs, the Naval Petroleum Reserve No. 4 (PET-4) was established by Executive Order No. 3797-1. The early reporting of oil seepages at Cape Simpson, Ensign Howard's discovery of oil shale along the Etivuluk River, the description of resources found in the North Slope by Peters and Schrader, and Leffingwell's mapping of the area, were all used to decide on the borders of PET-4. However, the geology and the geography of the PET-4 interior areas were still largely unknown, and it was necessary to increase the level of mapping and data gathering on the area.

From 1923 through 1926, USGS parties crossed the Brooks Range and PET-4 and mapped the geology and geography along many of the larger rivers, including the Kuk and Utukok rivers in the west and the Etivluk, Killik, and Colville rivers in the east (Smith and Mertie 1930).

The USGS team, P. Smith and J. Mertie, also analyzed the petroleum potential of the Reserve. They concluded that the best possible sources of petroleum were in the apparently widespread oil shales, while the sources of oil in the Paleozoic rocks were problematic. They did not believe the Cretaceous rocks held much potential for petroleum, as they thought the organic-rich rocks were thin and sparse. Additionally, they concluded that the Cretaceous source rock in the Brooks Range was too deep for practicable drilling. They recommended that evaluating the petroleum potential in the PET-4 would be best realized by drilling for stratigraphic and structural information near Cape Simpson, and then by pursuing additional geologic field studies and drilling in other favorable areas.

1940 to 1968

Government-Sponsored Exploration and Development Activities

In 1943, the Bureau of Mines sent a field party to the North Slope to investigate oil and gas seepages, in response to inquiries from the Alaska Defense Command and Territory of Alaska officials. The field party examined and sampled the Cape Simpson seepages, as well as several additional sites along the Arctic Coast. Samples were collected from 12 separate sites, and seepages were confirmed along Skull Cliff, Dease Inlet, Cape Simpson, Fish Creek, Brownlow Point, Manning Point, and Umiat Mountain.

In 1944, the first modern program of exploration, drilling, and geophysical and geological surveys was started by the U.S. Navy, and USGS geologic traverses began along the Colville River, later expanding to all major north-flowing rivers of the North Slope. In 1946, overland travel was necessary for the detailed structural geologic mapping. Weasels, military-style tracked vehicles, were used to cross the Brooks Range by four different routes, covering much of interior area of the PET-4. By 1950, almost every stream capable of floating by boat was also traversed. Helicopters were first used for geologic studies in the Anaktuvuk Pass area; aerial photographs of over 70,000 square miles of the PET-4 and adjacent areas helped geologists interpret the possible geologic structure of the area, and a special series of photos were also used to analyze and plan field surveys by the USGS.

Between 1945 and 1952, geophysical studies, including experimental airborne magnetometer and gravity and seismic surveys, were completed and covered a large part of the Reserve. The seismic surveys covered about 67,000 square miles, which included areas outside of PET-4, the gravity-meter surveys covered about 26,000 square miles, and the airborne magnetometer surveys covered 75,000 square miles, nearly all of the Arctic Coastal Plain and much of the foothills of the North Slope. Travel and housing of the geophysical crews was by tractor-sled trains, smaller tracked vehicles, and small aircraft.

In 1944, the first drilling locations were determined by the presence of the seepages at Cape Simpson and a reconnaissance of the Umiat Anticline. It was decided that drilling should be limited to depths less than 10,000 feet, thought to be the economic limit at the time. In February and March of 1945, supplies were sledded to Umiat, where a drilling and logistic support camp was established and drilling began. The Umiat oil field, however, was not discovered until 1950, and still remains undeveloped. However, Umiat is still an important operating base for air transportation and geophysical and geological operations and current leaseholders in the area are studying development.

Also in 1945, 31 shallow core tests were drilled at Cape Simpson. Oil was produced, but the estimated reserves were considered too small to justify additional development. By

1948, geophysical surveys indicated the presence of a large basement high under the Barrow high and led to drilling near the top of the high. Gas was discovered, but neither oil nor hard rock basement was found at a depth of 2,500 feet. This area is now referred to as the Barrow Arch, the north limb of the Colville Basin.

In 1949, high sulfur, heavy oil was found at a test well drilled near the Fish Creek seepage at a depth of 3,000 feet. However, no structure was found and no reserve estimate was made, and continued geophysical exploration around the Barrow high found no significant oil reserves. Given the discovery of oil at Umiat, and the mapping of several closed anticlinal structures in and adjacent to PET-4, it was thought that further potential was in the northern foothills. Therefore, 10 shallow test holes were drilled on 6 structures; 1 gas field and 3 prospective gas fields were discovered, and 2 closed structures were mapped in the western part of PET-4. Test wells were drilled, and gas was discovered at Meade, while the Kaolak test was dry.

From 1945 through 1952, 45 core tests and 36 well tests were drilled within and adjacent to PET-4. The results showed one large oil field—Umiat, one large gas field—Gubik, one small gas field—Barrow, three prospective gas fields—Meade, Square Lake, and Wolf Creek, and two small oil deposits at Cape Simpson and Fish Creek.

In 1947, the U.S. Navy, Bureau of Yard Docks, established and developed a research facility at Barrow. This was an important development for the Barrow community and for the exploration and development of the North Slope petroleum reserves. By May of 1947, a building program began to provide housing and laboratory facilities for the Arctic Research Laboratory, Office of Naval Research, and in August of 1947, the Office of Naval Research occupied these new facilities. To more fully acknowledge the U.S. Navy's contribution to Arctic research, the Arctic Research Laboratory became the Naval Arctic Research Laboratory in the mid-1960s.

In 1949, the discovery of gas at Barrow was likely the most significant result of the PET-4 project to the people of Barrow. The South Field is the oldest producing gas field in Alaska and the South and East Gas fields are the farthest north producing oil or gas fields in North America. When the PET-4 project arrived in 1944, Barrow was home to about 400 inhabitants; the exploration activities provided employment opportunities for the local people and the population quickly increased.

In 1953, the PET-4 program was unexpectedly halted. By then, additional drill sites had been selected and supplies had started to arrive at a location east of PET-4, in the southern foothills near the head of the Shaviovik River and at another location at the head of the Utukok River in the southwest corner of the Reserve. Most of the supplies were later returned to Barrow and Umiat.

In 1964, Congress granted permission to extend the gas supply from nearby gas fields to Barrow, and the village was completely converted to natural gas by 1965. The gas was supplied by the U.S. Navy at a subsidized cost and use was unlimited. The Barrow community remains dependent on this gas supply for heat and power.

After the PET-4 program was recessed in 1953, the entire camp facility at Barrow was turned over to Office of Naval Research until December 1954, when the Air Force took over the management of the base camp to support the Distant Early Warning-Line program. The Air Force continued to operate the base camp through civilian contractors until October 1971, when the operation was returned to the U.S. Navy. During that period, Office of Naval Research continued to manage the laboratory through a contract with the University of Alaska.

In 1980, the National Arctic Research Laboratory was decommissioned and the camp and all facilities were turned over to the U.S. Department of the Interior. From 1980 through 1984, the laboratory and camp facilities were managed by the USGS and their contractor, primarily as a base of operation for the Barrow Gas Fields. In 1984, the National Arctic Research Laboratory and the base facilities were turned over to the local Native corporation, Ukpeagvik Iñupiat Corporation (UIC).

State and Federal Leasing and Industry-Sponsored Exploration Activities

In the mid- to late-1950s and early 1960s, a number of factors prompted industry exploration of the North Slope for oil and gas resources. Although industry was historically interested in the North Slope, the lack of land availability, remoteness, and high costs associated with operating in the area had previously precluded industry participation.

The factors that contributed to the entry of industry into the North Slope exploration scene were an overall encouragement of regional geological studies, the PET-4 program, the discovery of commercial quantities of oil and gas in Cook Inlet, and the end of the land availability moratorium on the North Slope, the latter of which was likely the most important factor in attracting industry to the area. The oil and gas found in the Cook Inlet demonstrated that it was economically feasible to explore for, develop, and sell hydrocarbons in and from Alaska. In 1957, Richfield Oil made the initial discovery of significantly commercial Alaskan oil at Swanson River, on the Kenai Peninsula, and brought industry interest back to Alaska.

After the Federal government's decision, through the BLM, to make lands available for leasing, a total of 18,862 leases were offered in sales held in 1958, 1964, 1965, and 1966 (Jamison et al. 1980). Most of the sales were to the east and southeast of PET-4, however the lease sale in 1966 contained 3,022,716 acres to the west of PET-4.

In addition to the federal government lease sales, the State of Alaska selected 1,616,745 acres across the northern tier between the Colville and Canning rivers, to be offered for lease between 1964 and 1967. In 1964, the State's first lease sale on the North Slope offered 650,000 acres in the Colville River Delta area, and 196 tracts totaling about 475,000 acres were leased. In 1965, the State's second North Slope lease sale offered 754,000 acres, and 151 tracts totaling 380,000 acres were leased. Richfield-Humble acquired 28 blocks on what is now the crest of the Prudhoe Bay oil field, and British Petroleum acquired 32 blocks on the flanks. During the third State lease sale, in 1967, Richfield-Humble acquired 7 of the 13 tracts offered and leased; the 7 tracts covered the remainder of the crestal area of the Prudhoe Bay field.

In 1958, Sinclair operated a 3-month field program out of Umiat in preparation for the Federal lease sale that year. In order to gain a better understanding of the subsurface geology and the hydrocarbon potential of the region, many companies began to gather geological data during summer field programs and geophysical, primarily seismic, during winter seismic operations. Following Sinclair, an average of five to seven companies were in the field during the 1959 through 1961 seasons, and up to 10 companies per year were operating geological field programs from 1962 through 1964. Field programs began to decline after 1964 and thereafter only two or three companies were in the field per year.

In 1962, Sinclair and British Petroleum operated the first industry seismic data collection program, with the first seismic season consisting of about 6.5 crew-months. The crew-months grew to about 29 in 1963, peaked at about 53 in 1964, and decreased to about 27 in 1965. There was little seismic acquisition between 1965 and 1968, until the season following the Prudhoe Bay discovery (discussed below).

In 1963, industry began exploratory drilling, based on leasing, geologic fieldwork, and seismic acquisition. Eleven dry wells were drilled between 1963 and 1968. Colorado Oil and Gas Company drilled in the Gubik area, followed by seven other private wells, all of which were drilled on leases acquired in the first round of Federal lease sales. No discoveries were made. The wells were located in the foothills, within 30 miles of either the Umiat or Gubik discoveries, near the areas that had shown the most promise during the Navy's previous exploration efforts.

After the initial failure of the drilling programs in the Umiat-Gubik area, industry shifted efforts to the north and east areas of the North Slope. During 1966 and 1967, Sinclair and Union each drilled a well on the eastern flank of the Colville High; both wells were dry. During the same period, ARCO-Humble drilled another dry well, Susie No. 1, in the northern foothills of the Brooks Range. The decision was made to take the rig 60 miles north to drill in the Prudhoe Bay area, rather than releasing the rig.

In April of 1967, drilling began for Prudhoe Bay State No. 1. In January of 1968, ARCO-Humble announced the discovery of oil and gas with a recoverable economic reserve estimate of 9.6 billion barrels of oil and 26 trillion cubic feet of gas.

At this time, there were little to no geologic and seismic programs on the North Slope and, other than Prudhoe Bay State No. 1, all drilling activity had ceased. However, with the discovery at Prudhoe Bay, and the State's announcement for an additional lease sale in the fall of 1969, industry substantially increased the level of exploration activities on the North Slope. The geological and geophysical programs grew to 12 geological crew-months and 24 seismic acquisition crew-months in 1968 and 20 and 97 crew-months, respectively, in 1969 (Jamison et al. 1980). Additionally, in 1969, several other oil accumulations were discovered: the Kuparuk, West Sak, and Milne Point fields.

In September of 1969, the Alaska State Competitive Lease Sale No. 23 was held, offering 179 tracts totaling 450,858 acres—the unleased portion of the State's 1,600,000-acre allotment for the Statehood Act. With an average price per lease of $2,181.66 per acre, high bids on the 164 of the 179 tracts totaled more than $900,000,000. This was the last sale on the North Slope for 10 years (Alaska Department of Natural Resources 2001a).

1969 to 2012

Between 1969 and 1979, there were no additional lease sales held on the North Slope or the adjacent waters of the Beaufort Sea, making land accessibility the limiting factor for industry activity. Beginning in 1979, however, the shallow State waters and Federal Outer Continental Shelf areas of the Beaufort Sea were made available through a series of lease sales, and additional onshore sales were held in the Colville-Canning area. The State offered 71 tracts (341,140 acres) and granted leases on 62 tracts (296,308 acres). This sale marked the first major venture into offshore leasing in the Arctic by either the State or federal governments. The State continued to offer lease sales through the 1980s and 1990s. The State of Alaska has offered areawide sales on the Beaufort Sea since 2000, with their latest lease sale in 2011. The tracts offered are located within the North Slope Borough and consist of State-owned tide and submerged lands in the Beaufort Sea between the Canadian Border and Point Barrow. The 2006 sale received bids on 76 tracts for approximately 231,680 acres, which was twice the acreage received in 2004 covering 113,570 acres. To date, approximately 21 tracts are leased in Harrison Bay, east of Lake Teshekpuk, and 31 tracts have been leased in the Smith Bay area, northwest of Lake Teshekpuk (Alaska Department of Natural Resources 2006).

Table 4-37 lists the discoveries, dates of initial production, and cumulative production for oil and gas fields on the North Slope. Individual oil pools have been developed together as fields that share common wells, production pads, and pipelines. Fields have been grouped into participating areas (or production units) sharing common infrastructure, such as processing facilities, roads, and pipeline systems. Table 4-38 provides information on existing infrastructure to 2001. A map showing the location of these developments and the general infrastructure interconnecting them is shown in Map 3.2.6-2. All of these fields, with the exception of Northstar, Endicott, Sag Delta North, and Eider, are onshore on state leases. The Niakuk, Point McIntyre, and Badami oil pools are mainly offshore, but are produced from onshore sites.

The following discussion of the post-Prudhoe Bay activity focuses on four geographic areas that have different degrees of accessibility and economics. These are the Colville-Canning area and Beaufort Sea State waters, the Beaufort Sea Outer-Continental Shelf, the Chukchi Sea Outer-Continental Shelf, and the NPR-A. The onshore areas frequently contain some combination of State/Native or federal/Native land ownership.

Colville-Canning Area and Beaufort Sea State Waters

Through the 1970s, the area between the Colville and Canning rivers, from the Beaufort Sea south to the Brooks Range, was the sole area of industry exploration on the North Slope. Because of limited land availability and the success at and near Prudhoe Bay, this area has been the focus of exploration activity since the discovery well was drilled in 1968. The bulk of exploration and drilling has been concentrated in the northern portion of the area, near Prudhoe Bay and east and west along the coastline, following the structural trend of the Barrow Arch. The State leasing program that began in 1979, in the shallow state waters of the Beaufort Sea, is generally confined to a 3-mile-wide strip seaward from the shoreline and from Barrow to the Canadian border. The issue of ownership becomes somewhat irregular in the vicinity of the barrier islands and major inlets.

Table 4-37. Past oil and gas development on the North Slope

Unit/area	Field/satellite	Year discovered	Year began	Oil and condensate		Natural gas		Natural gas liquids	
				2010 (Mbbl)[1]	12/31/2010 Cumulative (Mbbl)[1]	2010 (MMcf)[1]	12/31/2010 Cumulative (MMcf)[1]	2010 (bbl)]	Cumulative (bbl)
Past Production and Development									
Duck Island	Endicott	1973	1987	300	455,856	11,494	2,608,945	28,713	24,566,362
	Sag Delta North	1989	1989	--	8,178	--	6,587	--	--
	Eider	1998	1998	--	2,754	--	27	--	--
	Ivishak	--	--	4	8,283	3	6,782	8	112,925
	Sag/Ivishak undefined	--	--	18	372	8	650		
Prudhoe Bay	Prudhoe Bay	1967	1977	8,107	11,279,570	251,730	63,944,034	1,885,148	560,884,213
	Lisburne	1968	1981	245	157,245	4,473	1,778,827	34,823	16,003,843
	Niakuk	1985	1994	105	90,421	128	79,918	2,278	1,150,888
	West Beach	1976	1994	--	3,374	--	20,041	--	220,306
	North Prudhoe Bay	1970	1993	--	1,986	--	6,651	--	84,922
	Pt. McIntyre	1988	1993	700	429,466	6,208	1,007,393	53,557	10,745,175
	Pt. McIntyre undefined	1988	1997		33		30		600
	Midnight Sun	1998	1999	56	18,475	68	58,175		
	Aurora	1999	2001	183	30,035	337	95,636		
	Borealis	1999	2001	275	61,895	529	70,766		
	Orion	2001	2003	280	21,909	236	21,619		
	Polaris	1999	2001	162	11,274	113	11,201		
	Put River			30	1,699	47	1,192		
	Raven	2004	2005	15	2,618	64	13,989	983	141,764
Kuparuk River	Kuparuk	1969	1981	2,813	2,222,332	7,202	2,934,306		3,345,638
	Tabasco	1992	1998	60	16,374	8	2,694		
	Tarn	1992	1998	319	101,032	420	160,092		

Table 4-37. Past oil and gas development on the North Slope

				Oil and condensate		Natural gas		Natural gas liquids	
Unit/area	Field/satellite	Year discovered	Year began	2010 (Mbbl)[1]	12/31/2010 Cumulative (Mbbl)[1]	2010 (MMcf)[1]	12/31/2010 Cumulative (MMcf)[1]	2010 (bbl)]	Cumulative (bbl)
	West Sak	1969	1998	496	51,657	233	24,394		
	Meltwater	2000	2001	67	15,099	376	35,554		
	Palm	2001	2002						
Milne Point	Milne Point	1969	1985	532	227,117	452	123,654		
	Cascade	1993	1996						
	Schrader Bluff	1969	1991	287	64,215	102	39,175		
	Sag River	1968	1994	14	2,283	16	2,306		
	Ugnu		2003	--	17	--	3		
Badami	Badami	1990	1998	34	5,255	217	28,986		
	Undefined			12	24	6	13		
Colville River	Alpine (CD-1 and CD-2)	1994	2000	1,885	349,599	2,202	421,661		
	Fiord (CD-3)	1999	2006	702	31,897	682	23,741		
	Nanuq (CD-4)	2000	2006	24	788	27	1,693		
	Qannik			75	2,220	43	2,035		
Northstar	Northstar	1984	2001	537	147,896	16,771	1,174,062		
	Kuparuk C Und			48	52	972	1,086		
Oooguruk	Kuparuk			152	5,604	138	4,293		
	Nuiqsut			119	1,445	77	718		
	Torok			12	135	1	36		
Past Production and Development									
National Petroleum Reserve-Alaska	East Barrow	1974	1981			80	10,000		
	South Barrow	1949	1950			53	23,000		
	Walakpa	1980	1993			1,255	16,400		
	Umiat	1946		41[2]	70,000[3]				

1 Annual and cumulative production of oil and gas are from Alaska Oil and Gas Conservation Commission 2011 (Mbbl=thousands of barrels, MMcf = million cubic feet).

2 Total of oil produced on formation tests from Umiat test wells 1946-1952 (Collins 1958).

3 Kumar et al. (2002).

Table 4-38. North Slope oil infrastructure (1968-2001)

	1968	1973	1977	1983	1988	1994	2001
Gravel roads							
Oil field (miles)	0	100	139	294	358	370	400
Oil field (acres)	0	677	1,002	2,029	2,448	2,536	2,745
Dalton Highway (miles)[1]	0	170	170	170	170	170	170
Dalton Highway (acres) [1]	0	332	332	332	332	332	332
Gravel pads							
Production, processing, support, exploration (facilities)	4	100	158	277	325	341	353
Production, processing, support, exploration (acres)	14	901	1,981	4,570	5,552	5,692	5,811
Airstrips	1	15	19	20	20	20	20
Airstrips (acres)	6	136	252	287	313	313	287
Offshore islands	0	0	2	12	15	16	17
Offshore islands (acres)	0	0	5	54	133	149	155
Gravel mines							
In rivers (acres)	25	4,732	4,996	5,011	5,063	5,061	5,082
In tundra (acres)	0	34	151	745	1,179	1,186	1,283
Pipeline corridors (miles)							
Oil field[2]	NA	NA	NA	NA	NA	NA	450
Trans-Alaska Pipeline[3]	0	166	166	166	166	166	166
Tundra impacted areas (acres)							
Gravel footprint areas[4]	20	1,714	3,240	6,940	8,446	8,690	8,998
Other impacted areas[5]	308	1,388	1,552	1,694	1,698	1,762	1,765
Gravel mines	25	4,766	5,146	5,756	6,241	6,247	6,364
Total disturbed area (acres)	353	7,868	9,938	14,390	16,385	16,689	17,127

1. Does not include portions of the highway south of the North Slope.
2. Multiple pipelines are included in some corridors (e.g., 366 miles have 1-5 pipelines and 73 miles have 6-11 pipelines).
3. A buried gas pipeline (10 inches in diameter for 34 miles and 8 inches for 110 miles) roughly parallels the oil pipeline south to Pump Station No. 4; mileage only includes those on the North Slope.
4. Includes gravel roads, gravel or paved airstrips, and offshore and onshore gravel pads/islands. Excludes causeways.
5. Includes exploration site-disturbed area around gravel pad, exploration airstrip, peat roads, tractor trail, exploration roads, and gravel pad removed.

NA -- Not available. Source: National Research Council (2003).

Seismic activity was at a high in 1970 with 96 crew-months. This decreased to 8 crew-months in 1972, and then grew back to 54 crew months in 1974. Following the high level of activity generated by the Prudhoe Bay discovery, geological and geophysical crew activity decreased sharply in the early 1970s and then slowly increased and stabilized to 25 crew-months by the late 1970s. In the early 1970s, geological field programs averaged about 20 crew-months per year. By 1974, this decreased to 6 crew-months and averaged 5 to 6 crew-months through the remainder of the 1970s (Jamison et al. 1980). During the 1980s and 1990s, the amount of fieldwork varied considerably, but the activity never reached the levels seen in the 1960s and 1970s. Over the last decade, geological activity has averaged 1 to 3 crew-months per year. Unlike seismic acquisition and exploration drilling, geological field activity frequently takes place external to the principal area of exploration interest. Much of the fieldwork was carried out in the Brooks Range to the south and in the Sadlerochit and Shublik Mountains of the Arctic National Wildlife Refuge.

Since 1980, the level of seismic acquisition has varied, but likely averaged less than 20 crew-months per year. One of the major reasons for this decrease has been the departure of several companies and the merger of former competitors. Also, the existing regional seismic grid was found to be of sufficient quality to allow companies to more finely tune their seismic acquisition and focus on specific areas. The more recent seismic acquisitions tend to be 3-D programs that provide a more detailed image of the subsurface than do the 2-D surveys. Seismic 3-D programs are too costly to be acquired on a truly regional scale and are generally limited to a maximum of 500 to 600 square miles.

The Arctic Slope Regional Corporation and several Alaska Native Claims Settlement Act village corporations have entered into exploration agreements with petroleum companies. No competitive leasing process is utilized to make lands available to industry and negotiations are generally confidential. Chevron, Texaco, ARCO, and Unocal have had such agreements in the past. Anadarko Petroleum and its partners currently have an exclusive exploration agreement with Arctic Slope Regional Corporation for nearly 3 million acres in the foothills of the Brooks Range. With recent interest in development of a gas pipeline, new seismic data were acquired in the foothills area during recent winter seasons. These seismic programs included both 2-D and 3-D acquisition technologies. Through ASRC's exploration agreements with various companies, exploration wells have been drilled on Native corporation lands on the North Slope (Alaska Oil and Gas Conservation Commission 2012). In addition to drilling in the Colville-Canning area, exploratory drilling has also taken place on Native corporation lands west of the NPR-A, in the NPR-A, and in the Arctic National Wildlife Refuge. One discovery was made on Native lands in the Colville River delta. The data acquired on Native corporation lands are usually kept confidential to the corporation and its industry partners.

From 1970 to the end of the century, there were at least 35 discoveries on State lands (Table 4-37 on page 20). These range from the currently uneconomic Kavik (discovered in 1969) and Kemik (discovered in 1972) gas fields in the east-central portion of the Colville-Canning province to large oil discoveries at Endicott (discovered in 1978) and Alpine field (discovered in 1994). A significant undeveloped resource is the Point Thomson oilfield (discovered 1977). The field is located just to the west of the mouth of the Canning River and contains reserves estimated at 8 to 9 trillion cubic feet of gas and 250 to 300 million barrels of liquids (both natural gas condensates and oil. With existing infrastructure in place and the prospect for additional infilling and a development at Point Thomson, the Colville-Canning area has been, and is likely to continue to be, a primary focus for North Slope oil and gas activity.

Twenty-five of the existing discoveries are either developed and in production, or are currently being developed. At least seven or eight of the discoveries are satellite fields and would not have been developed if they were not adjacent to a large field with an existing infrastructure. Tabasco and the Midnight Sun/Sambuca fields are satellites, each of which has oil reserves of 30 to 70 million barrels.

The most recent fields to be developed in this region are associated with the Alpine oil field. Most of the field's current development is in the Colville River delta east of the NPR-A, though some satellites may eventually be developed on BLM-managed surface or at least drain BLM-managed subsurface within the NPR-A. The Alpine oil field and satellite developments encompass approximately 890,000 acres of Federal, state, and private lands. In 1996, ARCO announced that the Alpine Prospect in the Colville River Delta was producible and contained an estimated 365 million barrels of oil. More recent estimates of Alpine oil field reserves, however, are near 500 million barrels. In November of 2000, production began in the Alpine field. Combined production from the original Alpine field (CD-1 and CD-2) and the three currently developed satellite fields (Fiord, Nanuq and Qannik fields) is 102,500 barrels of oil per day (Alaska Division of Oil and Gas 2009). Oil handling and seawater injection facilities were expanded in 2004 to allow for 140,000 barrels of oil per day.

The CD-1 pad serves as an oil processing facility and is connected to CD-2 by a 3-mile long road. Infrastructure at the existing CD-1 pad fully supports the ongoing drilling and production operations, including activities at the CD-2 field and satellite fields (CD-3 and CD-4). Oil is transported back from the satellite pads to the central processing facility at CD-1 through utility pipelines. Facilities and equipment currently installed include processing facilities, production wells, camp facilities, sanitation utilities (water and wastewater), a drilling mud plant, an airstrip, a maintenance complex, warehouse buildings, disposal wells, an emergency response center, and communications, power generation, and various mobile equipment (USDOI BLM 2004b). Oil is transported through a 34-mile pipeline to a central production facility in the Kuparuk River Unit, where Alpine field oil production is commingled with that of other fields in the area. Alpine field oil is then transported via the main Kuparuk River Unit pipeline to Pump Station 1 of Trans-Alaska Pipeline System. The Alpine oil field pipeline to the Kuparuk River Unit crosses under the Colville River channel. Ice roads and bridges provide access during the winter; otherwise, there are no overland routes to this isolated field. There are no gravel roads connecting the road system in Kuparuk River Unit to the Alpine oil field. The footprint of the Alpine oil field infrastructure, excluding the pipeline to the Kuparuk River Unit, is approximately 170 acres.

ConocoPhillips Alaska, Inc. also plans to develop three additional satellites (CD-5, GMT-1, and GMT-2) west of the Nigliq Channel of the Colville River. The proposed surface infrastructure is anticipated to be on Kuukpik Corporation surface estate, though horizontal drilling would likely recover petroleum from BLM-managed subsurface within the NPR-A from both of the Greater Mooses Tooth pads. (Consequently, GMT-1 and GMT-2 are described in "Resource Potential and Petroleum-related Activities" in section 4.2.1.2 (Volume 2) and are part of the direct and indirect analysis of the alternatives. CD-5, also sometimes referred to as Alpine West, is considered part of the cumulative impact scenario. Although this satellite is a short distance west of the Colville River, it would be a satellite in the Alpine field and for convenience is discussed in the Colville-Canning area.) In 2003, ADNR estimated that satellites CD-3 through CD-7 (CD-6 and CD-7 have since been redesignated as GMT-1 and GMT-2) could produce a total of 330 million barrels of oil in the next two decades

(Alaska Department of Natural Resources 2003). ConocoPhillips Alaska, Inc. proposes to connect these three satellites—each about 10 acres—to CD-1 via a road as are CD-2 and CD-4; CD-3 is roadless, but has an airstrip. Gravel for the satellites would be obtained from the existing Arctic Slope Regional Corporation Mine Site and the Clover Potential Gravel Source within the eastern NPR-A. The gravel pads are or are projected to be at least 5 feet above the surrounding tundra. Above-ground pipelines are anticipated to be at least 7 feet above the tundra at vertical support members and both industry and local residents would use the gravel roads. Final design, however, is not certain because ConocoPhillips Alaska, Inc. has not completed permitting to enable construction of these satellites or the infrastructure to connect them to CD-1 via a bridge across the Nigliq Channel.

The State of Alaska is currently undertaking permitting activities for a proposed road to connect Umiat at the southeastern edge of the NPR-A to the Dalton Highway. While meeting the criteria for a present action, readers should see the discussion of that proposal in the reasonably foreseeable future development scenario in section 4.8.3.2. Although not a part of the state's road proposal, oil and gas development along the road, including a pipeline that may extend from the Umiat area to Trans-Alaska Pipeline System, none of which is currently proposed, are more easily discussed in conjunction with discussion about the proposed road.

Beaufort Sea Outer Continental Shelf

Although previous reconnaissance seismic surveys were conducted in the Beaufort Sea, leases in the Beaufort Outer Continental Shelf were not offered to industry until the joint State of Alaska/federal lease sale of 1979. Subsequent sales provided access to waters beyond the 3-mile limit, stretching from approximately 125 statute miles west of Point Barrow (along 162 degrees west longitude) in the west to the Canadian border in the east. Including the 1979 lease sales, the Beaufort Outer Continental Shelf has been the site of 10 lease sales over a 26-year period.

The most recent sale, Sale 202, was held in April 2007 with 90 new leases covering approximately 500,000 acres. In past lease sales, over 800 leases have been issued in the Beaufort Sea, totaling over 3.7 million acres. One lease sale is scheduled in 2017 for the Beaufort Sea under the Bureau of Ocean Energy Management's 2012-2017 Outer Continental Shelf Oil and Gas Leasing Program.

The seismic data acquisition is different for onshore areas in northern Alaska as compared to offshore Outer Continental Shelf areas. The main difference is that onshore exploration typically occurs in the winter on a frozen tundra surface, whereas offshore activities often occur in the summer months with open water conditions. Limited offshore well control information is supplemented with onshore wells that are tied into the seismic grids to extend the geologic interpretations into the offshore areas. A combination of well and seismic data is used in the definition of potential prospects.

Seismic acquisition in the Outer Continental Shelf is not well documented in the public domain because the surveys are typically proprietary; however, commencing in the mid- to late 1970s, both summer marine and winter over-ice programs were acquired to correlate the better explored onshore geology into the Beaufort Sea. Most of the existing seismic data are 2-D, and 3-D seismic surveys are generally conducted near existing discoveries or prospects that are being prepared for drilling within the next few seasons. While the total line miles are not publicly reported, the total for 2-D seismic surveys is in excess of 100,000 line-miles. Information on historic and recent seismic surveys conducted in the Beaufort Sea Outer Continental Shelf planning area may be found on the Internet.[2] The existing seismic grid extends across state waters and ties into onshore wells or wells in the shallow near-shore portions of the Beaufort Sea. The acquisition area extends from near Point Barrow to the Canadian border.

The first Outer Continental Shelf exploration well was the Beechey Point No.1 in 1981, and the most recent exploration well was the McCovey No. 1 in 2002. The peak of exploration drilling was in 1985 and 1986, when 11 of the 30 exploration wells were drilled. A secondary drilling phase occurred during 1991 through 1993, when seven wells were drilled.

Depending on water depth, the Outer Continental Shelf exploration wells are drilled from either man-made gravel or ice islands, bottom-founded drilling structures or floating drillships. If a discovery is made and the field developed, a more permanent structure will be installed to hold year-round production facilities.

Nine of the Outer Continental Shelf exploration wells are determined to be capable of production (USDOI Minerals Management Service 2001b). Of these, five are termed significant discoveries: Tern/Liberty (discovered in 1982), Hammerhead/Sivulliq (discovered in 1985), Harvard/Sandpiper (discovered in 1986), and Kuvlum (discovered in 1992). The fifth discovery was the Seal Island/Northstar field, which underlies both Federal and state acreage (Alaska Department of Natural Resources 2000, USDOI Minerals Management Service 2001b) and began oil production in 2001.

Liberty, Sandpiper, and Northstar are in relatively shallow water (20 to 40 feet) near the well-established Kuparuk and Prudhoe Bay infrastructure. The Hammerhead and Kuvlum discoveries are 60 miles to the east of the Prudhoe Bay field, in 100 feet of water.

In August 2011, the Bureau of Ocean Energy Management issued conditional approval for a revised Exploration Plan submitted by Shell Offshore Inc. (Shell). In September 2012, the Bureau of Safety and Environmental Enforcement (BSEE) announced that Shell would be allowed to move forward with certain limited preparatory activities in the Beaufort Sea.

Chukchi Sea Outer Continental Shelf

Leases in the Chukchi Outer Continental Shelf area have been offered in three sales (1988, 1991 and 2008). The 1988 lease sale was the first areawide sale in the Chukchi and offered 4,694 lease blocks with a total of 25,631,122 acres. A total of 350 leases were issued covering 1,976,912 acres. The 1991 sale was much smaller, leasing 28 lease blocks for a total of 159,213 acres (USDOI Minerals Management Service, List of Alaska Region Lease Sales, September 2006). All leases were relinquished by the mid-1990s and industry interest was dormant for over a decade. However, new technologies and higher oil prices led to a renewed interest in the Chukchi Outer Continental Shelf.

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[2] http://alaska.boemre.gov/re/index.htm

In 2008, Sale 193 resulted in a total of 487 leases purchased by industry for nearly $2.7 billion. Because areas within 25 miles of the coast were not offered for leasing, the closest tract to receive bids in the 2008 lease sale was approximately 50 miles from shore in over 100 feet of water. One lease sale is scheduled in 2016 for the Chukchi Sea Outer Continental Shelf under the 2012-2017 Outer Continental Shelf Oil and Gas Leasing Program.

Five exploration wells were drilled in the Chukchi Outer Continental Shelf from 1989 to 1991 (Diamond, Popcorn, Crackerjack, Burger, and Klondike) with significant geologic information in most wells, although no wells confirmed potentially commercial discoveries. The Burger well had oil and gas shows and modeling estimates of possible resources of approximately 14 trillion cubic feet of gas and 724 million barrels of condensate were reported (USDOI Minerals Management Service 2001).

On July 21, 2010, the U.S. District Court for the District of Alaska (District Court) remanded Sale 193 to the Department of the Interior to address specific concerns related to NEPA analysis conducted prior to the sale, and suspended activities on the leases at issue. The Bureau of Ocean Energy Management responded by preparing a Final Supplemental EIS to address the District Court's concerns, and on Oct. 3, 2011, the Department of the Interior affirmed Lease Sale 193. On February 13, 2012, the District Court issued a decision in which it found the Final Supplemental EIS adequate, lifted the suspension of activities, and dismissed the matter in its entirety. On April 12, 2012, the District Court's decision was appealed to the U.S. Court of Appeals for the Ninth Circuit, where a decision is pending and a stay has not been issued.

The Bureau of Ocean Energy Management (BOEM) has received a revised exploration plan from Shell in support of the company's proposal to drill up to six wells on lease blocks within the Burger prospect starting in 2012 and continuing until the drilling program is completed. In August 2012, the Bureau of Safety and Environmental Enforcement (BSEE) announced that Shell would be allowed to move forward with certain limited preparatory activities in the Chukchi Sea and some preliminary site work was accomplished. See the BOEM website for details.[3]

The Bureau of Ocean Energy Management has received a draft exploration plan from ConocoPhillips, Inc. in support of the company's proposal to drill up to two wells among six proposed sites on lease blocks within the Devils Paw Prospect starting in 2013.

National Petroleum Reserve–Alaska

In 1974, the high prices of oil and the 1968 discovery of oil at Prudhoe Bay renewed interest in PET-4. The U.S. Navy began a small exploratory program, and in 1975, the Navy awarded a 5-year contract to Husky Oil, Inc., to manage and conduct a full-scale petroleum exploration program in PET-4. The focus of the exploration work was in the northeastern portion of the Reserve where it was believed that it would be most likely to encounter an extension of the Prudhoe Bay productive zones.

In 1976, PET-4 was renamed the National Petroleum Reserve in Alaska. Oversight of the Reserve was transferred from the Navy to the U.S. Department of the Interior and the USGS was assigned several tasks including (1) continuing the program of exploration begun by the Navy, (2) continuing operation and management of the Barrow gas fields, and (3) completing the cleanup program, begun by the Navy, of the Reserve and adjacent areas. Between 1974 and 1982, 28 test wells were drilled, and although indications of oil or gas were found in nearly all of the test wells, no deposits were found that warranted development. In addition, six exploratory and development wells were drilled in the Barrow area to supplement the local gas supply. Exploratory drilling by the USGS ended in 1981 when the NPR-A was opened up to leasing.

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[3] http://www.boem.gov/About-BOEM/BOEM-Regions/Alaska-Region/Leasing-and-Plans/Leasing/Index.aspx

Nearly 15,000 miles of seismic survey were acquired and interpreted between 1974 and 1982. Seismic activities covered 1,440 miles in 1976. In 1977, seismic surveys covered approximately 1,500 miles, primarily in the Foothills Province; this area and the Brooks Range were again explored in 1978 when 1,916 miles were surveyed. In 1979, 1,900 miles of seismic survey was obtained, including use of the Vibroseis method, rather than explosives. Much of the work was focused in the foothills area between Umiat and the western boundary near Icy Cape. In 1980, 1,096 miles of seismic surveys were run, with one party in the coastal area and the other in the foothills and Brooks Range. Most of these surveys were for fill-in reconnaissance. During 1980 and 1981, seismic activities slowed, as it became apparent that Congress would open the NPR-A to private exploration, which occurred in December 1980.

The federal leasing program in the NPR-A commenced in 1982 with two lease sales in January and May. Most of the acreage was located in the south and southeastern portions of the NPR-A. A total of 271 tracts, totaling 5,035,772 acres, were offered in the two sales, and 38 tracts, totaling 927,965 acres, were leased. The leased activity was focused in the areas west of Nuiqsut, west of Umiat, and west of the Lisburne well. In both sales, the lessees appeared to be pursuing Umiat play-types. In July of 1983, a third sale was held, where 84 tracts and 2,195,845 acres were offered, spread across the northern portion of the NPR-A; 20 tracts, totaling 419,618 acres, were leased (USDOI BLM 1990b). These tracts appear to have been selected to evaluate Prudhoe Bay play-types and were largely concentrated in the area between Admiralty Bay and the Chukchi Sea. A fourth sale was scheduled for July 1984, but was cancelled after no bids were submitted on the 64 tracts and 1,550,677 acres offered (Weimer 1987, Banet 1991).

The leasing in the early 1980s resulted in the drilling of only one industry exploration well (Brontosaurus 1) within the NPR-A, located in the western portion about 40 miles south-southwest of Point Barrow. The hole was dry and all other plans to drill were abandoned. Additionally, in the area northeast of Teshekpuk Lake, Chevron in 1982 drilled the Livehorse well on Native lands on Cape Halkett.

After the discontinuance of leasing in 1984, a 15-year hiatus in leasing activity and exploration in the NPR-A took place. It was not until after the 1994 discovery of the Alpine field in the Colville River Delta area that the government recognized the renewed industry interest in the NPR-A. After the discovery of the Alpine field, and in preparation for pending sales in the NPR-A, the major participants in ongoing North Slope exploration began to conduct 2-D and 3-D seismic programs in the probable sale area. The total line-miles of seismic data acquired are not known. There were at least seven 2-D programs acquired between 1992 and 1997 totaling 2,615 line-miles. A single 3-D program was shot in 1996 and covered an area of 152 square miles (Kornbrath et al. 1997). There were additional 2-D and 3-D programs acquired since 1997; however, the number of programs and coverage are not known.

The BLM reinstituted leasing in the Northeast NPR-A in May 1999. Approximately 3.9 million acres were offered, drawing 133 high bids on 867,721 acres. The bulk of the leased areas are in the vicinity of Nuiqsut and between Teshekpuk Lake and the Ikpikpuk River. After the 1999 sale (Sale No. 991), the industry began a drilling program in the northeastern portion of the NPR-A. Three wells were drilled in the winter of 2000, six wells were drilled in 2001, and an additional four wells were drilled in 2002. Most, if not all, of these wells were probably targeting Alpine-style prospects. An additional sale was held in 2002, where a total of 60 tracts with 579,269 acres were leased. This leased acreage is generally to the south and west of previously acquired leases. Subsequent to the 2002 sale, eight wells were drilled over the next four years, all but one in Northeast NPR-A. Four wells were drilled in the 2007 winter season, one of which was in the Northeast NPR-A. The remainder of the wells is located in the Northwest NPR-A planning area. In the winter of 2008, one well was drilled in the Northeast NPR-A.

Following signing of the Northwest IAP/EIS ROD, BLM held a lease sale in 2004 for 484 tracts of land within the Northwest NPR-A and another 22 tracts that are combinations of Northwest NPR-A and planning area lands, totaling approximately 5.8 million acres. Bids were received and leases issued on 123 of the tracts, totaling 1,403,561 acres. Another lease sale was held for the Northwest NPR-A in 2006. The sale offered 478 tracts totaling 5.4 million acres. As a result of the sale, leases were issued on 81 tracts totaling approximately 940,000 acres. The BLM held additional lease sales in Northeast NPR-A in 2008 and 2010. The 2008 lease sale offered 450 tracts totaling 4.8 million acres and leases were issued on 78 tracts totaling approximately 850,000 acres. The 2010 sale offered 190 tracts totaling 1.8 million acres; bids were received and leases issued on five tracts totaling 28,444 acres. The BLM held a sale for selected tracts within the Northeast and Northwest NPR-A in 2011 in which 283 tracts totaling a little over 3 million acres were offered. Industry bid on 17 tracts and all were issued as leases by the BLM. On October 4, 2012, the BLM announced a Detailed Statement of Sale in the Federal Register for the Nov. 7, 2012, NPR-A lease sale.

At least five of the post-1999 exploration wells drilled in the NPR-A have discovered oil and/or gas. The sizes of the discoveries have not been made public and available data are insufficient to make a precise calculation of the volume of oil and gas discovered, However, the USGS estimates (Houseknecht et al. 2010) that 120 to 200 million barrels of oil (including oil and condensate) and 1.9 to 3.0 trillion cubic feet of gas may be technically recoverable from these accumulations.

Cleanup and Rehabilitation Activities on the North Slope

Concurrent with exploration in the 1970s was a greater awareness of the need to protect the Arctic environment from exploration activities and to clean up debris left from earlier exploration activities. Equipment and supplies that were previously hauled by D-8 Cat trains, sometimes during the summer with the blade down, were now moved in winter by Rolligons—large vehicles with low-pressure balloon-like tires. In 1975, the Navy began preparing an EIS for activities in the northeastern portion of PET-4; this EIS would later expand to cover the entire Reserve and was completed in spring 1977. As part of the Final EIS, the Navy, in cooperation with the USGS, drew up stipulations concerning winter road and trail construction.

In 1976, drilling fluids from a site near Teshekpuk Lake broke through a retaining berm and flowed into Teshekpuk Lake. Although the amount of damage to the environment was minimal, all future reserve pits were designed to contain the total estimated volume of drill cuttings and muds below the level of the original tundra surface.

In 1976, a cleanup program was initiated, based out of Point Lonely and Barrow. During the summer of 1976, over 23,500 drums were retrieved and 750,000 pounds of debris collected. In 1977, another 26,500 drums and 485 tons of debris were collected. In 1978, over 2 million pounds of debris were collected, primarily from the Skull Cliff Air Force Tower site and the Navy's Topagoruk and East Topagoruk test well sites. In 1979, another 1.8 million tons of debris were collected at old Navy sites and other sites in the NPR-A.

Rehabilitation of pads and other disturbed sites began in the late 1970s, with the focus on lowering the drill pads and obliterating their straight edges, filling reserve pits, and revegetating sites. Germination success varied depending upon growing conditions during the summer; wet and foggy summers usually resulted in poor germination. It is estimated that about 550 acres were disturbed during the 1975-1982 USGS exploration program, that revegetation was attempted on 440 acres, and that vegetation became well established on nearly 400 acres by 1982.

Erosion along the Beaufort Sea coast and the shore of Teshekpuk Lake early this century threatened to inundate the well head and breach the mud pit at four legacy wells: J. W. Dalton, Atigaru, East Teshekpuk, and Drew Point. A series of winter mobilizations was conducted from 2004 to 2010 to plug and abandon these wells and dispose of contaminated soils in accord with Alaska Department of Environmental Conservation requirements. The wells were plugged with cement, excavated, and cut off well below the estimated eventual elevation of the encroaching sea or lakebed. Soils were hauled to approved inland disposal sites, which are regularly monitored to ensure there is no discharge to the environment. The new top caps on the wells are monitored to ensure that they are stable.

4.8.3.2 Reasonably Foreseeable Future Exploration and Development

Reasonably foreseeable future exploration and development includes future exploration, development, and production activities, including support and transportation components that would be associated with extraction of discovered oil and gas fields or discovery and extraction of yet undiscovered oil and gas in areas with existing oil leases or for which land managers are planning to hold lease sales. The developments most likely to occur and those that would occur soonest generally would be near existing fields, where infrastructure systems could be shared. The development that could occur in the NPR-A as a result of decisions in this plan are part of the cumulative scenario. The other major oil and gas activities that could cause cumulative impacts are:

- Road and pipeline between Umiat and the Dalton Highway,
- Chukchi Sea development,
- Beaufort Sea development,
- Commercial gas pipelines,
- Conventional oil and gas development in the Colville-Canning area, and
- Unconventional oil and gas production east of NPR-A.

Road and Pipeline between Umiat Area and Dalton Highway

The State of Alaska in the fall of 2010 initiated its application for permits to construct an all-season industrial gravel road to connect Umiat in southeast NPR-A with the Dalton Highway. Although the proposed road is to be designed to safely accommodate industrial traffic in arctic conditions, the road may eventually be open to the public as well as industry. The Corps of Engineers is the lead agency on an EIS for the proposal and is considering several alternative routes. The state's proposed route would start on the Dalton Highway approximately four miles north of Galbraith Lake and follow the Itkillik River north-northwest before veering west to cross the Anaktuvuk River below the Nanushuk River and then the Chandler River and ultimately the Colville River at Umiat. This route would be approximately 102 miles long, culminating with a bridge over the Colville. A variation of this route would leave the Dalton Highway south of Pump Station 3. Other more northerly routes to a bridge across the Colville are under consideration. One would extend about 95 miles from the existing Meltwater oil field southward along the Itkillik River before swinging west to Umiat. Another would traverse about 95 miles westward from near Pump Station 2. It would cross the most rivers—the Toolik, Kuparuk, Itkillik, Anaktuvuk, Chandler, and Colville.

The State projects that about three quarters of the traffic on the road will be industrial. The annual average traffic might resemble that of the northern Dalton Highway with annual daily traffic of 100 vehicles, though with approximately twice as much use per day during the summer (May through September) as in the rest of the year. (Melissa Riordan to Jim Ducker, Sept. 15, 2011) Besides the road and bridges, the project would include pullouts, maintenance facilities, temporary construction camps, and gravel material sites. The footprint of the development is unknown, but at an estimated 7.5 acres of footprint per mile of the 30-foot-wide road, it and the ancillary facilities and material sites from which gravel would be extracted would roughly total 1,000 acres.

The state hopes that the proposed road will help promote oil and gas development in the area and within the NPR-A. Depending upon which route is ultimately chosen, different potential oil and gas resources may be more easily accessed and development abetted. Oil and gas developments along the road including at Umiat would send resources out of the area by pipeline. An oil pipeline would likely be placed on vertical support members approximately 7 feet above the tundra. A gas pipeline would likely be buried. It is possible that pipelines would take a more direct route to Trans-Alaska Pipeline System or a future gas pipeline than the road if the Meltwater or Galbraith Lake road route is adopted. See page 41 for a summary of cumulative impact scenario conventional oil and gas development infrastructure in this area.

Chukchi Sea Exploration and Development

Industry is in the early stages of renewed exploration and planning for development of Chukchi Sea leases purchased in the Minerals Management Service (now the Bureau of Ocean Energy Management) lease Sale 193 in 2008. (Note: While the following discussion focuses on development in the federal waters, development in state waters could be explored and developed in a similar manner, except that shallow-water techniques, such as those discussed for the Beaufort Sea development on page 34 may be employed.) Exploration will include 2-D or 3-D seismic surveys to define prospective drill locations and delineate discoveries. These surveys will take place during the open water season (July-November) or in the presence of winter ice (in-ice; October-December). Typical 2-D or 3-D survey operations will consist of a large seismic vessel, two chase/monitoring vessels, and/or an icebreaker for surveys occurring in-ice. During exploration seismic surveys, the vessels are largely self-contained, so there would be a minimum amount of helicopter flights (assume one per day) to transport personnel, seismic data, and light supplies. Surveys would be completed within about two months.

Exploratory drilling operations are likely to employ drillships with 6 to 15 support vessels, including an icebreaker. A newly designed jackup rig, with associated support vessels, is also under consideration for exploration drilling. Exploratory drilling would occur between July and the end of October, during which period up to four wells could be drilled per season. Water depths greater than 100 feet and possible pack-ice incursions during the open water season are constraints to selecting suitable drilling platforms for the Chukchi Outer Continental Shelf. In 1989-1991, five exploration wells were drilled in the Chukchi using drillships that allowed the operator to temporarily move off the drill site, if sea or ice conditions require it. The suspended well is controlled by blowout-prevention equipment installed in well cellars excavated into the seabed.

The Bureau of Ocean Energy Management, in the high price scenario of their 2012-2017 Outer Continental Shelf Oil and Gas Leasing Program Final Programmatic EIS (USDOI BOEM 2012; see p. 4-658), projected that assuming an oil price of $160 per barrel and gas prices of $11.39, up to 6.23 billion barrels of oil and 24.75 trillion cubic feet of gas could eventually be produced from federal waters in the Chukchi Sea. This production would occur over 40 to 50 years. There would be up to 54 exploration and delineation wells, 880 platform production wells, and 235 subsea production wells. The Bureau of Ocean Energy Management assumed that to transport the oil and gas would require 1,000 miles of offshore pipelines and 500 miles of onshore pipelines. The wells would require 48 service vessel and 48 helicopter trips per week. The Bureau of Ocean Energy Management also projected 4 new natural gas processing facilities and 4 docks or causeways.

Drilling operations are expected to range between 30 and 90 days at different well sites, depending on the depth to the target formation, difficulties during drilling, and logging/testing operations. Considering the relatively short open-water season in the Chukchi (June-November), the Minerals Management Service estimated in their 2007 Lease Sale 193 EIS that up to four wells could be started by one rig each drilling season. However, the Minerals Management Service stated that it is more likely that only one to two wells could be drilled, tested, and abandoned during a single season, leaving work on the other wells to the next summer season.

Construction of a new shorebase would begin after a commercial discovery is made. Heavy equipment and materials would be moved to the coastal site using barges, aircraft, and perhaps winter ice roads. Transportation activities would be more frequent during the construction phase, beginning about 3 years after the discovery is made and will take another 3 years for completion of the new facility. During this construction phase, there could be one to two barge trips (probably from either West Dock or other staging ports) in the summer open water season. Aircraft (C-130 Hercules or larger) trips could be up to five per day during peak periods. The overall level of transportation in and out of the shorebase would drop significantly after construction is completed for both the shore base and offshore platform. During production operations aircraft would generally be smaller and arrive and take off at a rate of about two per day. Ice road traffic would be intermittent during the winter months.

Drilling wastes from exploration wells if permitted by a NPDES (National Pollutant Discharge Elimination System) permit could be disposed of on the ocean floor. Alternately, if local geological formations permit, drilling wastes could be disposed of in subsurface formations beneath the offshore platform or at an onshore disposal facility. Onshore disposal would require one barge trip per subsea template (four wells). This means that there could be two barge trips (during summer) to the new onshore facility while exploration drilling occurs.

The Minerals Management Service, in its 2007 EIS, and the Bureau of Ocean Energy Management (the successor agency) in its 2011 supplement to the 2007 EIS stated that processing (separation of oil, gas and water) would occur on offshore platforms. They projected that onshore development to support Chukchi Sea development would include a new coastal facility that would include administrative, maintenance, and housing infrastructure, as well as transportation facilities that may include a marine dock and airstrip along with roads connecting facilities. Transportation would be frequent during development, but drop once offshore facilities have been constructed. Thereafter, the Bureau of Ocean Energy Management estimated one to seven helicopter flights offshore per day and one vessel trip to the offshore facilities every one to two weeks. The marine traffic would be during the open-water period and possibly with ice-reinforced vessels during broken-ice periods.

The Minerals Management Service and Bureau of Ocean Energy Management projected that both the onshore oil and gas pipelines would be installed on vertical supports with construction occurring during the winter. The pipelines would run in a corridor across the NPR-A to existing facilities around Prudhoe Bay. Industry has not indicated a preferred pipeline route and the BLM considers it possible that a gravel service road would be constructed parallel to the pipeline to cross the NPR-A. A pump station for oil and compression station for gas would be located at the shore facility with two additional pump and compression stations located in the NPR-A. These would likely be collocated with oil and gas development facilities where practical. If a road is built, it would require sites with administrative, maintenance, and crew housing facilities along the route; these new facilities would probably be collocated with pump stations. Construction of a road and related facilities would add greatly to the cost of Chukchi Sea development, likely increasing the onshore gravel footprint (including mineral material sites) from perhaps less than 100 acres for a pipeline-only development to 3,000 acres. An all-season road, however, could expedite Chukchi Sea development, pipeline inspection and repair, and spill and leak response.

The time between leasing to production start-up would take approximately 15 years. The total life cycle of the offshore project could last 40 to 50 years. Upon abandonment, offshore pipelines would be decommissioned by cleaning, plugging both ends and leaving them in place buried in the seabed. Unless transporting NPR-A oil and gas can economically justify the continued operation of the overland pipeline the pipeline and other infrastructure would be decommissioned and abandoned with removal and rehabilitation similar to that described in section 4.8.3.6. The offshore platforms would be disassembled and removed and the seafloor will be restored to a pre-development condition. The abandonment process could take several years with environmental studies continuing beyond that.

If Chukchi Sea development results in pipelines and possibly other infrastructure in the NPR-A, oil and gas exploration within the NPR-A could be encouraged and marginal discoveries could be developed. (If a Chukchi Sea pipeline came ashore on the North Slope west of the NPR-A—lands the USGS estimated may contain 80 million barrels of technically recoverable oil (Attanasi and Freeman 2009), it could similarly encourage exploration and potentially discovery and production from North Slope land west of the NPR-A.) This could result in a synergistic increase in NPR-A production over that projected for the direct and indirect development scenarios. The large-scale infrastructure built for Chukchi Outer Continental Shelf development could make it economic to develop small, remote oil and gas fields along the transportation corridor that would otherwise be sub-economic. Marginal oil and gas accumulations located farther away from the hypothetical oil and gas pipeline corridor from the Chukchi Sea would remain sub-economic. With so many uncertainties about the location and quantities of oil and gas resources in the NPR-A and the route of future pipelines, it is impossible to determine the likely additional production that could result from the NPR-A. However, given that economics would be substantially improved for a narrow (e.g., 25 miles) corridor within the entire planning area near a pipeline route, the additional infrastructure spurred by the pipeline would be modest. Also, because the BLM optimistically assumes very high oil and gas prices, with correspondingly high levels of associated infrastructure, the added effects of the pipeline corridor would not be large.

Beaufort Sea Development

Geophysical exploration has occurred in the Beaufort Sea since the late 1970s with practices similar to those described above for the Chukchi Sea. Marine seismic surveys and exploratory drilling, which are anticipated to be continued in the Beaufort Sea, will take place during the open water season (July-November) or in the presence of winter ice (in-ice; October-December). Typical 2-D or 3-D survey operations will consist of a large seismic vessel, two chase/monitoring vessels, and/or an icebreaker for surveys occurring in-ice. During exploration seismic surveys, the vessels are largely self-contained, so there would be a minimum amount of helicopter flights (assume one per day) to transport personnel, seismic data, and light supplies. Surveys would be completed within about two months. Seismic surveys could also occur in state waters and could be conducted by on-ice vibroseis and ocean-bottom cable. Vibroseis surveys would occur in nearshore areas (primarily on state leases) on thickened sea ice capable of supporting the equipment during the winter months. Ocean-bottom cable surveys would be conducted during open water in nearshore shallow water zones. Ocean-bottom cable survey is used to acquire seismic data in water that is too shallow for large marine-streamer vessels and/or too deep to have grounded ice in the winter.

Depending on the distances involved, exploration wells in the Federal and state waters in the Beaufort Sea would be drilled by extended reach from shore-based wells or from man-made gravel or ice islands. In deeper water (greater than 15 meters), mobile, bottom-founded drilling structures could be used. Drillships with icebreaker support vessels are typically used in water depths greater than 25 meters. Artificial gravel or ice islands may be employed as drilling platforms in less than 15 meters of water, and their construction and supply would be supported by ice-roads across the landfast ice zone. In deeper water, bottom-founded structures and drillships would require supply vessels and helicopter support because they would not be accessible for vehicles.

Assuming a discovery is made and a new field is developed, a permanent platform would be installed to hold production wells and a facility. Previously developed offshore fields in the Beaufort (Endicott, Northstar, Oooguruk, and Nikaitchuq) were built on manmade gravel islands. Production platforms would include production wells, water injectors, gas injection wells, and waste disposal wells. Some of the natural gas produced would be used to power equipment on the facility, but most would be re-injected to maintain reservoir pressure. Produced water would also be reinjected (Alaska Department of Natural Resources 2000). The offshore production platform would be accessed by helicopter, barge, and in nearshore areas, by a winter ice road. A subsea pipeline would bring the petroleum into an onshore pipeline gathering system, where it would be processed, either in existing facilities or, if too distant from existing facilities, new processing facilities. If the field was located more than 25 miles from shore, as is the scenario contemplated in the Chukchi Sea, it is likely that processing would occur offshore. Once processed, the oil and/or gas would pass through existing or new pipelines, with new pump or compressor stations, if necessary, to the Trans-Alaska Pipeline System or a future market gas pipeline.

The Bureau of Ocean Energy Management in their 2012-2017 Outer Continental Shelf Oil and Gas Leasing Program Final Programmatic EIS (USDOI BOEM 2012) projected that assuming a high oil price of $160 per barrel and gas prices of $11.39, up to 1.10 billion barrels of oil and 7 trillion cubic feet of gas could eventually be produced from federal waters in the Beaufort Sea. This production would occur over 40 years. There would be up to 40 exploration and delineation wells, 310 platform production wells, and 25 subsea production wells. The Bureau of Ocean Energy Management assumed that to transport the oil and gas would require 423 miles of offshore pipelines and 290 miles of onshore pipelines. The wells would require 30 service vessel and 30 helicopter trips/week. The Bureau of Ocean Energy Management also projected 4 new natural gas processing facilities and 4 docks or causeways.

Development in the eastern Beaufort Sea, the area in which Shell currently plans to explore, would not be affected by decisions in the new IAP, nor would development in the central Beaufort OCS and on State of Alaska marine waters east of the Colville River. However, if the BLM adopts Alternative B-1, offshore development in the western Beaufort may be affected because that alternative prohibits permanent non-subsistence infrastructure along the entire NPR-A coast east of Barrow. New pipelines from the western Beaufort Outer Continental Shelf to existing infrastructure near Prudhoe Bay could make sub-economic oil and gas fields in the northern NPR-A viable to produce, at least under Alternatives A, C, and D. Development in the western Beaufort could synergistically benefit development in the northern NPR-A east of Barrow under Alternatives A and D or at least east of Tangent Point under Alternative C. The opportunity for synergistic onshore development would not occur under Alternative B-1 because support facilities for offshore development would not be permitted (see Map 2-2-1). Synergistic development is greatly reduced in Alternative B-2 compared to Alternatives A, C, and D. Although Alternative B-2 would present opportunities for onshore development in support of Beaufort Sea development, coastal lands and lands some distant inland would not be available for leasing (see Map 2-2-2). Under some conditions, Stipulation K-6 in each of the alternatives could allow minimal shore facilities, such as those associated with oil spill contingency staging and pipeline landfalls.

Commercial Gas Pipelines

Development of North Slope gas is a long-time dream of many Alaskans. As long ago as 1977 the Federal Energy Regulatory Commission completed an environmental impact statement for the Alaska Natural Gas Transportation System and later that year issued a certificate of public convenience and necessity for the project that would have brought North Slope gas south to Delta Junction and then to Alberta parallel the Alaska Highway. The Secretary of the Interior issued a federal right-of-way grant for the project in 1980, which was relinquished in 2008. Other projects have been proposed. Most notable among these was the Trans-Alaska Gas System, for which an EIS was completed in 1988 and a 30-year federal right-of-way grant issued by the BLM in 1988, which was relinquished in 2011. It would have brought gas to Valdez where it would be converted to liquefied natural gas for shipment (FERC 2006). But no development has occurred.

North Slope oil wells also produce natural gas and water but, without a gas pipeline to market, industry reinjects the gas that is not used for field operations back into the oil producing reservoir to improve oil recovery (but where it also remains available for commercial production). However, there have been substantial steps taken in recent years to bring about gas pipelines to take the stranded gas reserves to a market. In 2007, the State enacted the Alaska Gasline Inducement Act. Under it the state solicited proposals and selected Trans-Canada as the licensee to construct a gas pipeline from the North Slope to market, and Trans-Canada, which has since taken on ExxonMobil as a partner in what they have termed the Alaska Pipeline Project, held an open season in 2010 seeking shippers through the pipeline they propose to build. They solicited interest in two routes: one to Alberta following the Dalton, Richardson, and Alaska highways and one to Valdez, where a liquid natural gas export facility would be built, via the Dalton and Richardson highways. In April 2011, Alaska Pipeline Project, having completed its open season, announced that it would concentrate its efforts on the route to Alberta. That route would be approximately 1,700 miles. Alaska Pipeline Project's project includes construction of a $12 billion gas treatment plant at Prudhoe Bay. The pipeline would be 48 inches in diameter and carry up to 4.5 billion cubic feet of gas a day. It would be buried for nearly all of its length and cost up to $41 billion (2009 dollars). The pipeline would provide at least five points in Alaska from which spur lines could be built to provide gas to Alaskans. By the summer of 2012, Alaska Pipeline Project anticipates that it will have spent nearly $500 million of an anticipated $717 million on pre-construction studies, design, and permitting. Under the Alaska Gasline Inducement Act, the State will reimburse the Alaska Pipeline Project up to

$500 million of these costs. Alaska Pipeline Project applied to the BLM for a federal right-of-way grant in April 2010, and to satisfy conditions established pursuant to the Alaska Gasline Inducement Act originally planned to apply to the Federal Energy Regulatory Commission in October 2012 for a certificate of public convenience and necessity to construct and operate the pipeline to Alberta. The Commission's review would be expected to take about 2 years, and construction timelines would depend upon commitments from gas suppliers that are necessary to obtain construction financing. However, in May 2012, the State of Alaska granted a request by Alaska Pipeline Project for a two-year extension of the October 2012 deadline for which to file the certificate application with the Federal Energy Regulatory Commission, so that the Alaska Pipeline Project could focus its attention on evaluating an in-state route option that would terminate at a liquid natural gas export facility to be constructed at tidewater either in Valdez or elsewhere in Southcentral Alaska. Also, in May 2012, Alaska Pipeline Project closed out negotiations following the 2010 open season, after reporting that no precedent agreements for transportation service on the Alberta Project had been executed. In September 2012, Alaska Pipeline Project held a second open season, soliciting supplier interest for both the Alberta and liquid natural gas options, and Alaska Pipeline Project continues to negotiate with possible suppliers who expressed interest during the open season while it evaluates both options. Construction of the Alberta project may take 5 years.

The State of Alaska's Alaska Gasline Development Corporation has proposed construction of a 24-inch pipeline. It would be buried nearly all of its distance from Prudhoe Bay to the Big Lake area of Southcentral Alaska. The pipeline would parallel the Dalton Highway to the Livengood area, cut across the Minto Flats, and proceed south roughly paralleling the Parks Highway. After exiting a gas treatment plant at Prudhoe Bay, up to 500 million cubic feet of gas a day would pass through the pipeline. Including the treatment plant, the project is anticipated to cost between $5.3 and $9.8 billion. The Alaska Gasline Development Corporation anticipates design, engineering, permitting, and negotiating with potential customers to continue until 2015, followed with three or four years of ordering pipe and major equipment, followed by construction, with first gas flowing in 2018 or 2019. The Fairbanks Pipeline Company is studying a couple smaller pipeline ideas that would place either a 12-inch pipeline from Prudhoe Bay to Fairbanks or an 18-inch pipeline from Prudhoe Bay to Southcentral Alaska. (White 2011)

While severe economic challenges face all of the gas pipeline projects, for analysis purposes the BLM is assuming that the Alaska Pipeline Project's Alberta pipeline and the Alaska Gasline Development Corporation pipeline will be built. However, were the Alaska Pipeline Project to instead pursue a liquefied natural gas project to Southcentral Alaska, the impacts of that project would be very similar to that projected for the Alberta project, particularly on the North Slope, although the construction timeline would likely be delayed approximately 3 to 5 years beyond the timeline estimated for the Alberta project due to the fact that it would need substantially more analysis than currently exists.

The Alaska Pipeline Project submitted preliminary draft resource reports to the Federal Energy Regulatory Commission for the Alberta project in April 2011 in support of the then anticipated October 2012 application for a certificate of public convenience and necessity and a revised document in December 2011 (Alaska Pipeline Project 2011a and 2011b, respectively). Alaska Gasline Development Corporation submitted a grant of right-of-way application to the BLM in August 2010, a revised Plan of Development in March 2011, and a project plan on July 1, 2011 (Alaska Gasline Development Corporation 2010, 2011a, and 2011b, and USACE 2012, respectively). The following summaries of pipelines to bring North Slope gas to market are based on these documents.

Alaska Pipeline Project's Alberta project includes a gas treatment plant at Prudhoe Bay. Gravel pads and roads for the treatment plant would directly impact approximately 200 acres of land for the gas treatment plant site access roads, and expansion of a pad near West Dock for a module staging area. Gravel will be obtained from existing borrow sites.

Through its entire length in the North Slope, the pipeline would be buried and cooled to below freezing to minimize impact to permafrost. Two of the eight compressor stations anticipated for the pipeline would be on the North Slope, one near Happy Valley and one near Galbraith Lake. These compressor stations would sit on 25-acre pads. There will also be a metering station at Prudhoe Bay.

Access to the project throughout its length in Alaska will be provided by existing roads, such as the Dalton Highway and existing oil field roads on the North Slope, and existing airstrips. Where modifications or improvements are necessary, Alaska Pipeline Project estimates that gravel will be obtained from existing borrow pits.

The Alaska Pipeline Project estimated the land impacts along the pipeline on the North Slope would total 4,500 acres during construction and half that figure during subsequent operations. Alaska Pipeline Project arrived at these estimates by assuming impacts to all of a 200-foot construction right-of-way during construction and to all of a 100-foot permanent pipeline right-of-way. Construction camps, pipe storage areas, and contractor yards will, to the extent possible, be located at previously disturbed sites; Alaska Pipeline Project at the time of the drafting of the preliminary draft resource report had not determined which sites would be used or the need for any additional sites.

Before receiving a two-year extension from the State of Alaska to file an application with the Federal Energy Regulatory Commission for a certificate of public convenience and necessity, Alaska Pipeline Project anticipated that it would first dredge a channel for sealifting its gas treatment plant modules to the Prudhoe Bay area in 2016. Sealifts and construction of the gas treatment plant would have begun the following year and end in 2020. Maintenance dredging of the channel would have been required annually before each of three sealifts from 2017 to 2019. Clearing for the pipeline would have begun in 2016 and pipe laying and metering and compressor station construction would have begun in the winter of 2017-18 and ended by the summer of 2019. Maintenance and reclamation would have begun in 2018. Gas would have first entered the pipeline in 2020 and reached its full capacity the following year. However, given the two-year extension it is reasonable to assume that Alaska Pipeline Project now anticipates that each of these dates will occur two years later.

Construction activities will include surveying, clearing, grading, laying, welding, coating, and backfilling the pipeline, and cleanup and rehabilitation.

- **Surveying:** In addition to staking the centerline and right-of-way boundaries, known archaeological sites, wetlands, and other environmentally sensitive areas will be staked or fenced.

- **Clearing:** Clearing will typically occur in winter to remove trees and brush from the construction area using heavy equipment. For winter construction season, it will also include snow removal as necessary.
- **Grading:** Where necessary to level the surface heavy equipment. Loose material will be stored for later use in cleanup. During construction erosion control, such as diversion berms, surface drainage ditches, and French drains may be utilized.
- **Pipeline installation:** The trench for the pipeline will be made with heavy machinery, aided as necessary in areas of permafrost and bedrock with blasting. Individual pipe lengths of 40 to 80 feet will be trucked to near the trench, where they will be bent to match the contour of the right-of-way, welded together, joints coated, and lowered into the trench. The trench will be backfilled, importing additional fill to compensate for thawing and settling of ice-rich trench spoil material.
- **Cleanup and Rehabilitation:** Construction debris will be gathered and disposed of at approved off-right-of-way disposal sites. Surface drainage patterns will be reestablished. Generally, a crown of trench backfill material will be placed over the trench to compensate for settling. Loose organic material and stripped topsoil will be replaced. After installation of permanent erosion control devices, the work area will be seeded with an approved seed mix.

Gravel pads and roads will involve similar surveying and clearing techniques. Gravel will be placed directly on the ground to build up the pad to a prescribed thickness. Rigid insulation may be placed under the pad to reduce the amount of gravel required. Gravel will be acquired from existing or new gravel pits. Water will be needed to help compact the pad as well as to support operations. (Alaska Pipeline Project will furnish information on water needs in a subsequent report.)

Alaska Pipeline Project estimates that the peak workforce during pipeline construction would be 5,000 to 7,000 people, with individual spreads reaching 1,600 (the BLM assumes one spread at any time on the North Slope). Compressor stations will each take about a year to complete and require an additional 150 workers during construction. Work camps will range in size from 50 to 125 people for work such as clearing and borrow sites, to 75 to 150 at a metering station at Prudhoe Bay and at compressor station construction sites, to 750 to 1,600 for pipeline installation. The gas treatment plant will require up to 850 construction workers, with work extending from the fall or early winter of 2019 and extending to 2022.

Much of the Alaska Gasline Development Corporation's proposal is similar to that of Alaska Pipeline Project's Alberta project. It would have a gas treatment plant at Prudhoe Bay on a 70-acre pad with short associated access roads. The gas treatment plant would have a compressor. The pipeline would have, at least initially, one or two other compressor stations along its mainline (both south of the Brooks Range) that would accommodate a flow rate up to 500 million cubic feet per day. Depending upon the demand for gas throughput, Alaska Gasline Development Corporation acknowledges that additional compressor stations may be built. In its 2010 application, Alaska Gasline Development Corporation indicated that up to 11 compressor stations might be built and three of the 11 would be on the North Slope at approximate miles 58-62, 111-116, and 154-163. Gas would be cooled to below freezing before input into the pipeline and Alaska Gasline Development

Corporation anticipates that mechanical refrigeration will be used to cool compressed gas at compressor stations along the northern portion of the pipeline and will maintain pipeline temperature below freezing throughout its passage across the North Slope. A nearly half-mile permanent access road near the gas treatment plant would involve clearing about 2.75 acres. Alaska Gasline Development Corporation would construct two other access roads of approximately a quarter-mile length, one of a tenth of a mile, and 17 shorter gravel roads (13 permanent and four temporary) north of the Brooks Range. These new gravel roads along the route of the pipeline would involve clearing about 5 acres in addition to those cleared for the road near the gas treatment plant. Alaska Gasline Development Corporation also anticipates construction of six ice roads totaling less than half a mile in length all on the North Slope. Maintenance facilities would be located at Prudhoe Bay, Fairbanks, and Wasilla.

The pipeline would be buried at least 36 inches; the pipeline would be above ground for its first 6 miles south of the gas treatment plant and for short distances at several bridge crossings of larger streams and at compressor stations. Alaska Gasline Development Corporation anticipates that the construction right-of-way generally would be 100 feet (larger areas would be needed at pads for horizontal directional drilling under stream crossings and at construction camps and temporary laydown areas) and that the operational right-of-way would be 52 feet. Alaska Gasline Development Corporation has identified 49 existing material sites north of the Brooks Range along the Dalton Highway from which gravel may be obtained for construction of pads and roads. Alaska Gasline Development Corporation anticipates that along most of its route, including on the North Slope, there is sufficient material in these existing sites and hauling distances on the North Slope would not exceed 7 miles.

Alaska Gasline Development Corporation's application describes construction activities similar to those described by Alaska Pipeline Project. Preconstruction activities of surveying, clearing, grading, and development of material mine sites, camps, laydown yards, and, where necessary, additional access roads would occur the summer before pipeline construction. On the North Slope, construction north of Happy Valley would occur during the first winter (November-April), construction in the Atigun Valley to Atigun Pass would occur during the following summer (June-September), and construction in the intervening area would completed during the second winter. Blasting would be used to fracture high-density frozen soils or rock during trench excavation. Small crews will use mobile camps to conduct pre-construction work. During construction, 8.5-acre sites anticipated at Franklin Bluffs, Happy Valley, Galbraith Lake, Atigun, and Chandalar in or near the North Slope will accommodate 250 to 500 workers each. The gas treatment plant would be transported to Prudhoe Bay by sealift in modules and assembled in the second and third summers of construction.

Following pipe laying, the trench would be back-filled and crews would perform clean-up, including leveling the pipeline right-of-way, shaping a crown over the trench, installing permanent erosion controls, disposing remaining scrap material and debris, and seeding and fertilization. The backfilled ditch would be monitored to ensure that the vegetated mat grows in and erosion does not occur above the pipe. Material sites, campsites, and temporary access roads would be recontoured and restored. Once completed, Alaska Gasline Development Corporation that the pipeline may remain in operation for more than 50 years.

Employment on Alaska Gasline Development Corporation's pipeline would peak at about 6,400 in the second summer. On the North Slope, the first and second winter seasons would each see approximately 1,200-1,250 workers on the northern construction spread; approximately 700 workers would be needed in the summer season construction as the pipeline reached into the Brooks Range. During pipeline operation, approximately ten workers would be required at Prudhoe Bay to run the gas treatment plant and conduct operations and maintenance. A total of 40 other workers would be employed at Fairbanks and Wasilla.

Conventional Oil and Gas Development in the Colville-Canning Area

Additional amounts of conventional oil could be produced by enhanced recovery technology from existing fields and from undeveloped or undiscovered satellite pools adjacent to existing production areas east of the NPR-A. Because they would be satellites to the Alpine oil field complex in the Colville River Delta, the proposed CD-5 pad and other Alpine satellites that would exclusively drain non-federal lands west of the Colville River are considered as part of the Colville-Canning area. Some of the production in the Colville-Canning area would replace declining oil production at existing fields. It is reasonable to assume that a portion would be brought into production in the foreseeable future.

Presuming a gas pipeline is completed, commercial gas development could occur in the Colville-Canning area. Much of the initial gas for the gas pipeline would come from existing oil fields and would rely as much as practicable on the existing roads, pads, and other infrastructure. But the presence of a commercial gas pipeline would also spur additional development that could contribute both oil and gas production. Where oil and/or gas accumulations occur near existing infrastructure (but not close enough to be efficiently tapped by drilling from existing pads), they may be developed with new gravel pads and gravel roads connecting to the existing infrastructure. In such a case, they could utilize existing oil, or new centralized oil and/or gas, processing facilities, worker facilities, maintenance equipment, and storage facilities. Accumulations farther from existing infrastructure might be developed similar to the Alpine and Badami fields, which are not linked to the infrastructure at Prudhoe Bay by road and have their own oil processing, personnel, maintenance, and equipment storage facilities. This is the concept being pursued by ExxonMobil in their proposed development at Point Thomson. Access would most likely be provided by a mix of ice roads, air, and, if on the coast, barge.

There is good reason to believe that some of the earliest gas to be delivered through a commercial gas pipeline would originate from gas deposits readily accessible from existing infrastructure. However, the timing of gas production from specific existing infrastructure and known gas accumulations, and the development of new infrastructure to reach more distant gas accumulations, will involve complex technical, economic, and corporate considerations. Although it may be assumed that as a rule, gas accumulations closer to existing infrastructure, using existing infrastructure, would be produced sooner than other accumulations, and that gas accumulations farthest from existing infrastructure would be produced last, this may not always be the case.

The BLM is assuming that the growth of the future gravel footprint outside of the NPR-A due to oil and gas development would continue at a rate exhibited in recent years related to onshore and nearby Beaufort Sea development in the area east of the NPR-A. Prior to 1988, during which the main North Slope road system and most of the pads for the Prudhoe Bay and Kuparuk oil fields were built, the average annual gravel footprint growth was 421 acres. Between 1988 and 2001, the average growth rate was 42 acres per year (Table 4-38 on page 22). For analysis purposes, the BLM in this IAP/EIS is assuming that the total growth in the conventional oil and gas footprint in the cumulative geographic scope through this century could be 3,750 acres of gravel pads, roads, and airstrips and 750 acres of new or expanded borrow sites.

Unconventional Oil and Gas Development East of NPR-A

The severe geological, logistical, and economic challenges facing oil and gas development from source rock in the NPR-A are described in section 4.2.1.2. (Volume 2). No such development has occurred or proven to be possible on the North Slope. Nonetheless, Great Bear Petroleum LLC leased more than half a million acres primarily south of Prudhoe Bay in 2010 with the intention of exploring and developing source rock which it estimates could yield 2 billion barrels of oil and 12 trillion cubic feet of gas (Great Bear 2011). In December 2011, Great Bear added to its lease acreage five to ten miles west of the Dalton Highway; Royale Energy, Inc. also leased tracts to the east and west of Great Bear holdings. (*Petroleum News*, December 11, 2011). Given the challenges for unconventional source rock development, Great Bear and Royale Energy are taking some considerable risk. Nevertheless, they have some advantages in their lease selections. A number of Great Bear's tracts are along the Dalton Highway and some wells have been drilled from existing gravel pads. As noted in 4.2.1.2 in Volume 2, the requirement for a gravel road between pads and existing pipelines is one of the major challenges. Should Great Bear be successful in its initial exploration and be able to develop a viable project based along the highway, it and potentially Royale Energy will also have the advantage of relatively plentiful gravel supplies, at least in comparison to much of the NPR-A.

Since there has been no source rock development in Alaska to date and exploratory drilling began only in the summer of 2012, describing potential development for cumulative impact analysis involves many uncertainties. For the purposes of analysis, however, the BLM will assume that unconventional oil and gas development becomes viable on the better drained lands south of the super-giant Prudhoe Bay oil field and in the general area of the Dalton Highway. Further, we will assume that developing this resource will result in as much as 200 acres more gravel pads and roads (and up to 40 acres of gravel pit expansion) annually for 15 years for an initial rapid development of the infrastructure based on an assumption of pads as close as a mile apart and roads connecting pads. Thereafter, additions to the footprint would be relatively minor and be subsumed in the general assumption of approximately 42 acres of additional gravel footprint a year for conventional oil and gas development described on page 41.

4.8.3.3 Speculative Development

Speculative developments are those that the BLM does not consider reasonably foreseeable. They may include projects that are discussed in the public arena, but which are currently prohibited by law or for which there is no current concrete proposal before an authorizing land management agency. Speculative developments are not considered in the cumulative impact analysis.

Factors Contributing to Uncertainty

There are many factors that contribute to uncertainty regarding future oil development.

Prices

The price structure and stability for oil will play a pivotal role in the future of the petroleum industry in Alaska. When oil and gas prices are low, the high cost of producing petroleum in northern Alaska places North Slope crude oil at a disadvantage relative to low-cost areas. It also tends to use up funding for Alaskan projects by the producing companies who can realize a greater return on investments in lower-cost environments. When prices are higher, the return on investment is much greater and exploration and development opportunities become more attractive to industry on the North Slope.

Land Availability

Even with sustained high oil prices, there will be no significant reserve additions without attractive exploration opportunities. These opportunities only exist when there is a continued and diverse offering of exploration acreage. A successful exploration effort requires that a broad mixture of potential play types of a size sufficient to provide economically viable targets be made available in a predictable and systematic manner. In such a scenario, exploration would provide a spectrum of field sizes such that the larger accumulations generate the demand for the infrastructure, which would in turn create an environment in which smaller fields (satellites) may be profitable to develop.

Reserve Estimates

When exploration begins in a new area, like in the North Slope in the 1960s, no one has direct evidence of the true nature and distribution of potential reservoirs in the subsurface, let alone the presence or volume of hydrocarbons that may be present. Seismic data used to determine the presence of potential structures and traps, and outcrop exposures, often tens or hundreds of miles away, are the sole source of possible reservoir data. Based on these bits of information, a first prediction is made as to the probability of oil or gas being present, and then if the assumptions regarding structure, trap, reservoir, and source are reasonable, what range of hydrocarbon volumes the feature could contain. The reality of potential volumes, as revealed by exploration drilling, may be different from the pre-drill predictions. Original predictions for the size of some fields have turned out to underestimate (e.g., Prudhoe Bay) or overestimate (e.g., Badami) the actual oil endowment. The development of infrastructure such as occurred at Prudhoe Bay and Kuparuk and with the Trans-Alaska Pipeline System, made exploration for previously unrecognized or ignored nearby small accumulations feasible. This again contributed to a larger total reserve estimate.

Speculative Developments

Developments listed below are considered speculative. Consequently, impacts of these developments are not considered in this IAP/EIS.

Roads Connecting North Slope Communities

The communities of the North Slope are not connected by gravel roads to one another or other parts of the Alaskan road network. There are no known proposals to develop such roads. Consequently, the cumulative impact analysis does not consider such roads as reasonably foreseeable.

Arctic Ocean Shipping

The Arctic Ocean has experienced reduced levels of ice in recent years and it is anticipated that there will be declining ice cover in the future. This has raised the prospect for the opening of shipping routes in the Arctic Ocean, but the timing, amount, type, and routes of such shipping face numerous feasibility challenges so they must be considered as speculative at present.

4.8.3.4 Oil and Gas Production on the North Slope of Alaska

Production Through 2007

From 1977 to the end of 2009, North Slope developments produced 16.2 billion barrels of oil and natural gas liquids (Alaska Division of Oil and Gas 2009). Production on the North Slope peaked in 1988 at 2.0 million barrels of oil per day, declining to its current rate of approximately 0.6 million barrels per day (Petroleum News 2011). Of the producing fields on the North Slope, the most productive (in order of productivity) are Prudhoe Bay, Kuparuk River, Alpine, and Point McIntyre.

Future Oil and Gas Production Estimates

Table 4-39 provides estimates of economically recoverable conventional oil and gas for the area within the geographic scope used in the cumulative impact analysis. These estimates are based on Thomas et al. 2009, except that NPR-A figures are based on the recovery estimates provided in this plan in section 4.2.1.2 (Volume 2). The former document, produced by the Department of Energy's National Energy Technology Laboratory, reports economically recoverable oil and gas to 2098 based on exploration projections through 2050. For a discussion of potential unconventional oil and gas recovery, see section 4.8.3.2, page 42.

Table 4-39. Future production of conventional oil and gas used in the cumulative impact analysis, 2012-2100

Area	Oil (BBO)	Gas (TCF)
NPR-A	0.76	17.391
Colville-Canning (includes State Beaufort Sea)	3.15	33.3
Chukchi Sea Outer Continental Shelf	6.23	24.75
Beaufort Sea Outer Continental Shelf	1.1	5.75
Total	11.24	81.191

BBO = billion barrels of oil; TCF = trillion cubic feet

Sources: Sec. 4.2.1.2 for the NPR-A; Thomas et al. 2009 for Colville-Canning; USDOI Bureau of Ocean Energy Management 2011 for Chukchi and Beaufort seas. The table only includes the highest estimated recovery from the Outer Continental Shelf.

Note: The estimates of economically recoverable oil and gas for the NPR-A are those estimated in this plan for Alternative D. For the other alternatives, corresponding oil and gas estimates would be: Alternative A = 0.723 BBO/10.099 TCF gas; Alternative B-1 = 0.505 BBO/8.411 TCF gas; Alternative B-2 = 0.549 BBO/8.738 TCF gas; and Alternative C = 0.707 BBO/15.128 TCF gas.

4.8.3.5 Gravel Footprint and Mineral Material Sites

An important element in estimating environmental impacts associated with oil and gas activities on the North Slope is the gravel footprint. Development on permafrost soils such as exist on the North Slope rely on the use of gravel as the foundation upon which to build pads, roads, airstrips, and other infrastructure.

Table 4-40 summarizes the long-term total gravel and borrow site footprints assumed for purposes of cumulative impact analysis in this plan. The existing gravel footprint includes that for 2001 appearing in Table 4-38 plus an assumed annual addition since then. The rationale for the figures for future additions to the footprint appears in sections 4.2.1.2 (Volume 2) and 4.8.3.2, pages 31-42.

Table 4-40. Gravel and borrow site footprint assumptions

	Gravel Footprint (acres)	Borrow Site Footprint[1] (acres)
Existing footprint	9,500	6,400
NPR-A[2]	11,450	2,300
Road to Umiat	850	175
Chukchi Sea Development[3]	2,500	500
Commercial Gas Pipeline	350	35[4]
Colville-Canning/Beaufort Sea Conventional Development	3,750	750
Unconventional Development[5]	3,000	600
Total	31,400	10,760

1. The BLM assumes that new development would require approximately 1 acre of new or expanded borrow site footprint for every 5 acres of new pad. This is based on the ratio between 1988 and 2001 (National Research Council 2003).
2. These figures reflect the assumption for Alternative D and include development of both previously discovered resources in the existing units and at Umiat and the development of projected economically developable undiscovered resources.
3. These figures assume a road is built to parallel the pipeline(s). Without a road the gravel footprint likely would be less than 100 acres with a 20-acre borrow site.
4. Alaska Pipeline Project and the Alaska Stand Alone Gas Pipeline, upon whose documentation these assumptions are based, anticipates that much gravel will come from existing borrow sites. To be conservative, the BLM estimates 35 acres of new disturbance.
5. These figures represent the potential increase in the first 15 years of operation. Thereafter, unconventional growth in the footprint would be subsumed in the annual increase assumed for conventional development.

4.8.3.6 Infrastructure and Transportation

Production of any North Slope oil reserves would not occur without a means of exporting the production to market. The transportation infrastructure system for any project includes four components: pipelines from the production pads to a central processing facility, pipeline from the central processing facility(ies) to the Trans-Alaska Pipeline System or to one or more future gas pipelines, Trans-Alaska Pipeline System from Prudhoe Bay to Valdez or a gas line to market, and, in the case of oil, seagoing oil tankers that travel from Valdez to ports on the west coast of the U.S. and in Asia. (See the Commercial Gas Pipelines discussion above for more information on that potential future infrastructure.)

Given the decline of production in existing Prudhoe Bay fields, the existing oil transportation system (including the Trans-Alaska Pipeline System) is expected to be able to transport oil produced by development of new reserves on the North Slope, as well as additional enhanced recovery from the Prudhoe Bay fields during the cumulative analysis period. New fields would use infrastructure at the edge of the core area to transport processed crude oil to the Trans-Alaska Pipeline System. This existing infrastructure at the edge of the core area includes the Western Group (including existing Alpine, Kuparuk, and Milne Point infrastructure), which would accommodate new production from the NPR-A; the Central Group (including Northstar and other fields near the Beaufort coastline); and the Eastern Group (including numerous discoveries in the Point Thomson area and adjacent offshore; see Map 3.2.6-2).

The cumulative impacts of operating the Trans-Alaska Pipeline System transportation system were evaluated in the Final EIS for Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way (USDOI BLM 2002). These impacts included consideration of continuing use of the crude oil transportation system to transport current and future production. It also considered the probability and consequence of spills from various elements of the system. The conclusions about the cumulative impacts associated with transportation of crude oil from the North Slope presented in the Trans-Alaska Pipeline System Renewal FEIS are equally applicable to this IAP/EIS, and are incorporated into this cumulative analysis. A copy of the Trans-Alaska Pipeline System Renewal EIS can be reviewed online;[4] the findings are summarized below.

The Trans-Alaska Pipeline System Renewal FEIS made the following conclusions on impacts from continued operation of the pipeline and tanker transportation system:

- **Paleontology, Air Quality, Transportation, Waste Management, Terrestrial Vegetation and Wetlands, and Cultural Resources** – The Trans-Alaska Pipeline System would have no or a very minor impact.
- **Soils and Permafrost** – Increased throughput could expand thaw bulbs and ground settlement near the Trans-Alaska Pipeline System. Reduction in throughput could cause frost heaves. Overall, the Trans-Alaska Pipeline System would be a minor contributor to cumulative effects related to soils and permafrost.
- **Sand, Gravel, and Quarry Resources** – The Trans-Alaska Pipeline System would be a minor contributor to requirements for these resources.
- **Surface Water Resources** – Impacts to surface waters would be localized unless an oil spill occurred, in which case impacts could be substantial. The Trans-Alaska Pipeline System operation would have a very small effect on surface water quality.
- **Groundwater** – An oil spill from Trans-Alaska Pipeline System or oil development activities could impact groundwater quality to a small or large extent, depending on the spill's size, and location, and the effectiveness of response activities.
- **Physical Marine Environment** – The marine environment could be affected by spills from tanker and other forms of marine transportation in Prince William Sound or along Pacific transportation routes. Reasonably foreseeable

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[4] http://tapseis.anl.gov/

spills would be small, rapidly cleaned up, and of local consequence. Larger, less probable spills could take longer to clean up and result in widespread contamination of the marine environment.

- **Noise** – All activities would have the potential to produce local impacts on noise.
- **Human Health and Safety** – No substantial health impacts would be expected from the inhalation of industrial air emissions in the Valdez area. The Valdez Marine Terminal operations contribute to, but are not the sole source of, organic air pollution emissions in the Valdez area. The general public would be exposed to more vehicle emissions over the next 30 years unless additional controls were placed on such emissions. Accidental releases of hazardous materials and spills into the marine environmental also could have small impacts on public health.
- **Fish** – Risks of large spills with large consequences would be minor; however, a major spill into a waterway could be severe and possibly long term.
- **Birds and Terrestrial Mammals** – Impacts from many activities could be large in local areas but would be minor on the population level.
- **Threatened, Endangered, and Protected Species** – Impacts are anticipated to be negligible to minor and are not anticipated to threaten population viability, unless a low-probability, high-volume spill from oil transportation occurred in Prince William Sound or along Pacific transportation routes. Such a spill might cause impacts that would be high on a local level.
- **Subsistence** – There would be minor impacts on subsistence, except on the North Slope where impacts would be moderate. Contributions from TAPS to these cumulative impacts are expected to be relatively small.
- **Sociocultural Systems** – In sociocultural systems founded on cooperation and subsistence, cumulative impacts might accompany their continued interaction with modern American society and the continued growth in the importance of a cash economy. However, these changes occurring throughout Alaska are not attributable solely to cumulative actions considered in the EIS. The contribution of the Trans-Alaska Pipeline System to these cumulative impacts would be relatively small.
- **Land Use and Coastal Zone Management** – The contribution of the Trans-Alaska Pipeline System operation to these cumulative impacts is expected to be relatively small. However, an oil spill to marine waters from marine transportation or from oil production could impact implementation of Coastal Management Plans.
- **Recreation, Wilderness, and Aesthetics** – Oil or gas spills associated with Trans-Alaska Pipeline System operations could impact recreation, aesthetic, and wilderness values. Because spills could result in long-term impacts, aesthetic impacts along Trans-Alaska Pipeline System could be major.
- **Economics** – Continued production of North Slope petroleum reserves, including transportation, would make a substantial, though declining contribution to domestic oil production, and would continue to reduce the need for foreign oil imports, thus improving national energy security and the overall balance of trade. Substantial Federal tax revenue would be generated with

continued Trans-Alaska Pipeline System operation, together with marine and shipbuilding employment and employment in the economy as a whole.

4.8.3.7 Advances in Technology

When exploration of the North Slope began, knowledge about of the effects of exploration and construction techniques on permafrost was limited. From early exploration through the 1950s, trails often were cut directly into frozen ground. Large tractors and tracked vehicles traveled over thawed ground in the summer, often leaving deep ruts, and sometimes road builders removed the vegetation mat completely, causing deep thermokarst (Bliss and Wein 1972, Hernandez 1973, Chapin and Chapin 1980). Trails commonly became wetter than the natural habitat and were colonized by species more adapted to wet sites. Higher biomass and changes in nutrient concentrations occurred in the trails (Chapin and Shaver 1981). At times, subsidence and erosion created trails as deep as 16 feet (Lawson et al. 1978). Some old trails and seismic surveys made by government contractors in the 1940s are still clearly visible because they are deeply rutted, often flooded, and filled with vegetation that is quite different from the surrounding tundra (Hok 1969 and 1971, Lawson et al. 1978).

In the 1960s, peat roads were built by scooping the active layer from two sides of an area and piling it in the center to form an elevated surface. This method also resulted in severe thermokarst. By the 1970s, gravel had replaced peat in road construction. Now in many cases, ice and packed snow roads are used.

Over the past 2 decades, new technologies have been developed and applied to exploration, development, and production on the North Slope. Some technologies, such as the use of ice roads and ice pads for exploration wells and the Arctic Drilling Platform, are unique to the Arctic and were largely developed in Alaska. Other advances, such as the use of coiled tubing, 3-D seismic-data acquisition, horizontal and multilateral drilling, measurement while drilling, low ground-pressure vehicles (Rolligons), and remote sensing, were developed elsewhere and adapted for use on the North Slope. Although some of those newer technologies have been used extensively, and the newer fields (such as the one at the Alpine field) use them almost exclusively, older technologies are still integral parts of the older portions of the Prudhoe Bay and Kuparuk fields. An understanding of the development and use of newer technologies is important in understanding what effects to resources accumulate on the North Slope, and the likelihood and magnitude of these effects in the future.

Seismic, Off-Road Travel, and Exploration

The new exploration-related technologies reduced the overall use of gravel and presently eliminated it from the exploration-drilling process, provided data for better siting of facilities, and reduced the number of wells required to find and evaluate a new field. Although the physical effects have been greatly reduced by the use of these technologies, there are still valid concerns regarding the potential for some amount of damage to the environment.

The environmental effects of the older road and pad construction techniques and seismic trails are matters of concern. In some instances, the effects have not diminished with the passage of time; in others, a natural but slow recovery is occurring. The visual impact, in some cases, will be evident for years, if not for decades.

The density of 3-D seismic activities can cause short-term visual impact. In areas where there is little snow cover or steep vegetated terrain, damage to the tundra and shrubs can be locally significant and long lasting. Long-term studies of the trails built for the closely spaced 3-D acquisitions are required to document the potential effects. Improvements in 3-D seismic-data acquisition and other exploration technologies allow geologists to identify higher quality prospects and to improve success rates by as much as 50 percent or more. With the use of 3-D seismic-data acquisition, success rate increased to 48 percent in 1997 (U.S. Department of Energy 1999, Revkin 2001). In 1970, the success rate for exploration wells in the U.S. was about 17 percent. In addition to the advances in data quality and acquisition procedures, there have been important advances in the engineering of the vehicles used to move the camp equipment and to acquire the 3-D seismic data. The major changes have been in the development of new "light-weight" rubber tracked caterpillar-type vehicles and vehicle-mounted vibrators that do less damage to the tundra and shrubs than the older vintage steel-tired vehicles.

About 25 years ago, 3-D seismic technology was introduced. Data, acquired in a grid-like manner with the individual lines spaced only a few hundred feet apart, are computer manipulated to create multidimensional representations of the subsurface. The result is a far better understanding of the geologic structures and continuity of the potential hydrocarbon-bearing formations. As with the older generation 2-D seismic data, onshore 3-D seismic data are acquired during winter, after freeze-up. Vibrators are used and these energy sources and the crews, camps, and other support facilities are carried on and/or are usually towed by low-impact tundra travel vehicles (Lance 2000). Most offshore 2-D and 3-D seismic data are acquired during the open water season using airguns rather than vibrators. Some offshore data, in the area of bottom-fast ice, are acquired during winter using land technology.

The older, land-based 2-D seismic technology consisted of long, intersecting seismic lines that used either dynamite or vibrators as the energy source. In the early stages of acquisition on the North Slope, much less care was taken to protect the tundra from damage during data acquisition. Damage, then as now, can result from inadequate snow cover and inappropriate equipment.

Offshore seismic data are acquired using patterns and spacing similar to those used in onshore acquisition. These data can be acquired only when the sea is relatively ice-free and boats can maintain long uninterrupted traverses. A high noise level is associated with marine acquisition, and it negatively affects marine organisms, especially whales.

Four-D visualization adds the element of time to 3-D seismic databases. A reservoir's fluid viscosity, saturation changes, temperature, and fluid movements can be analyzed by time-lapse monitoring in three dimensions (U.S. Department of Energy 1999). The time-lapse picture is built out of data re-recorded, compared, and plotted by computer onto the 3-D model. Additional data, such as well logs, production information, and reservoir pressures, may be integrated into the time-lapse imagery. The resulting information provides geologists and others with data that are valuable for both exploration for and management of existing resources. The exploration element comes from the greater ability to predict the best locations for exploratory drilling.

The 3-D seismic-data acquisition and 4-D visualization technologies provide a number of environmental benefits (U.S. Department of Energy 1999). They include more accurate exploration well-siting that reduces the number of dry holes, the number and length of ice roads, and the number of ice pads that have to be built; generation of less drilling waste and decreased volumes of materials, thereby lessening the possibility of a spill or other accident; better understanding of flow mechanics so that less water is produced relative to oil or gas; and increased ability to tailor operations to protect sensitive environments. Overall, fewer wells are required in order to evaluate and produce the reserves.

Nonetheless, considerable concern has existed regarding the effects of any seismic activity conducted either on land during winter or at sea during the open water season (Van Tuyn 2000). Land-based seismic-data acquisition with its large vehicles and numerous traverses across the tundra has left scars of the vehicle paths, some of which have been slow to heal and recover. At sea, migrating bowhead whales have been deflected by noises generated by seismic exploration and drilling.

The 3-D seismic-data acquisition programs require more closely spaced grids, a few hundred feet between lines as opposed to several thousand feet with standard 2-D seismic programs. This closer spacing has the potential to affect a greater amount of the tundra surface. These trails are often highly visible the following summer, in part because the old dead vegetation has been flattened by the vehicles and the green new vegetation can be more readily seen in sharp contrast to the undisturbed surrounding areas.

The closer spacing of the seismic traverses may also increase the risk that denning polar bears may be disturbed. This risk could be lessened by studies of bear denning sites and planning the acquisition programs accordingly.

Ice Roads and Pads

Arctic tundra is easily disturbed and slow to recover from damage. Disruption of tundra may also have a pronounced effect on permafrost and result in thawing and erosion. Historically, roads to exploration well sites were built of peat, bladed bedrock, or gravel, causing long-term damage to tundra that remains evident after 40 or more years. Drilling pads were similarly built of gravel or bulldozed bedrock in some areas of the NPR-A during the Navy exploration efforts in the 1940s and 1950s. Because of these factors, and potential damage from transporting equipment across the tundra either in the summer or winter, ice roads have replaced gravel roads and have become the means of access to most isolated drilling locations. In a similar fashion, ice pads have become the standard for exploration drilling sites, eliminating the need for gravel to build pads and cleanup after drilling. All onshore exploration drilling is done during winter and all materials necessary for drilling a well, including the drilling rig, are moved to and from well locations on ice roads.

An ice road 6 inches thick and an average 30 to 35 feet wide would require 1 million to 1.5 million gallons of water per mile of length (Van Tuyn 2000); ice roads on the North Slope are generally 12 to 18 inches thick. Frequently, exploration activity within a specific area requires more than one drilling season; therefore, more than one ice road may be built from the staging area(s) to the same drilling site or prospect. To avoid possible damage from multiyear usage of the same area, any subsequent ice road is offset by at least a road width from previous ones.

A 6-acre drilling pad, 12 inches thick, would require approximately 500,000 gallons of water (Van Tuyn 2000). The ice pads provide a solid, stable base from which to drill an exploration well. Upon completion and abandonment or testing of the well, the rig and all support facilities are moved off location and the pad is allowed to melt. The result is a very low impact operation, and usually the only indication of the drilling activity is the abandoned wellhead.

In special situations, specifically where drilling and evaluation are expected to require either an extended drilling season or two drilling seasons, insulated ice pads have been utilized. BP Exploration used such a system when drilling the Yukon Gold No. 1 and Sourdough No. 2 wells in the 1993-1994 drilling season (U.S. Department of Energy 1999). A 190- by 280-feet ice pad was built in March 1993 and covered with wind-resistant insulating pads. The pads remained in place over the summer and were removed in October. Drilling began in mid-November, two months ahead of conventional Arctic practice. With this advanced drilling start, the Yukon Gold well was completed, and the rig moved to the Sourdough site and the well completed, all in the same season. This would have been impossible with a conventional ice pad.

To save time on equipment move-in, Phillips Alaska stacked a rig over the summer west of Teshekpuk Lake (120 west of Kuparuk) on an insulated ice pad during 2003-2004. The pad of ice was constructed toward the end of the winter and covered with wind-resistant insulating panels over the summer months. The drilling rig was then moved to the insulated pad site the following winter. A drilling season can be increased by 50 to 70 days by employing this method (CRS Report for Congress, 2006).

There is the potential for some level of short-term damage in areas that have either experienced low snow fall or removal of snow by high winds, thus creating substandard snow cover conditions. However, in most instances, there is little evidence of either the ice road or ice pad once the snow cover is gone.

The use of ice road and ice pad technology reduces the need for gravel during the exploration phase of oil and gas activity. Smaller volumes of gravel are mined during the history of a given field, less area is covered by gravel, and there is little recognizable damage to the tundra. The use of an insulated pad allows the drilling of more wells in a single season, reducing the need to build ice roads in two seasons to serve the same general area.

The older technologies had greater potential to seriously disrupt tundra, thaw permafrost, and mar the viewscape. These effects can persist for many years and many damaged sites have not been adequately remediated. Although the use of ice roads and pads has largely eliminated those problems, a different set of potential effects has been identified. Insulated ice pads have some degree of influence on the underlying tundra, because the area loses a growing season, but these effects have not been studied.

The construction of ice roads and pads relies on a ready and plentiful supply of water. Water is withdrawn from rivers or lakes, and existing ice is crushed or chipped and spread along the prescribed roadway or pad site. Concern has been expressed that the extraction of such large volumes of water may endanger fish and drinking water resources. Areas such as the Arctic National Wildlife Refuge have low lake densities and a reliable source for water to build ice roads/pads may not be present. At this time, there are few reliable data that address the controversy over the appropriate use levels for water in the construction of ice pads/roads.

Rolligons and the Arctic Drilling Platform

Potential problems associated with exploration drilling in areas with limited freshwater supply or shortened ice road seasons may be alleviated by the use of low ground-pressure vehicles (Rolligons) and the Arctic Drilling Platform. Low ground-pressure vehicles put 1 to 5 pounds per square inch (psi) of footprint pressure on the tundra. The vehicles with 1.0-2.0 psi are used for building snow trails. (Lewellen Arctic Research and Polar Alpine, Inc. 2000). Once the lowest pressure vehicles have compacted the trail, higher pressure vehicles can be used. This can effectively extend the off-road winter season on the North Slope. Low-ground pressure vehicles have been used to move drilling rigs to remote locations. Their primary use would likely be to access locations that are far from current infrastructure and where the economies of the operation favor their use over the costs and the associated delays of building an ice road.

Anadarko field-tested a new drilling system, the Arctic Platform, which has potential for use in the NPR-A, although this is unlikely due to the "pioneering" nature of this technology. The Arctic Platform is like an offshore platform, but is used on land. A self-contained drilling system and crew quarters sit atop a deck made of interlocking modules that rest on pilings set into the permafrost below the tundra. The platform is elevated approximately 12 feet off the tundra, eliminating the need for gravel or ice pads, and rests on a base of shallow containers that capture any deck fluids or other spillage. Surface use of this technology could allow operators to perform exploration drilling outside the winter season, since ice pads would not be required. This technology could also allow access to remote areas, to areas where water to build ice roads is scarce, and to areas where steep grades make it difficult to set a rig. The Arctic Platform concept may have promise for exploration drilling and as a production unit. At this time, however, it is still in the experimental or developmental stage and, consequently, for the purposes of this analysis, it is assumed that this drilling system will not be used.

Seismic exploration is expanding southward into the foothills of the Brooks Range. Current technology and regulations governing seismic-exploration permits and other off-road travel have reduced but not eliminated damage to the tundra. The nature and condition of permafrost in the foothills is poorly characterized, and the hilly topography increases the likelihood that vehicles would damage vegetation, especially on knolls and riverbanks, causing increased erosion, exposing bare soil, and creating thermokarst. In addition, future exploration would be carried out in a climate that is likely to continue to warm, with milder winter temperatures and shorter periods of freezing.

Drilling and Completion Technologies

An oil reservoir is part of a porous and permeable layer of rock in which the oil is trapped. On the North Slope, each production well is designed to produce from a subsurface area of at least 80 acres. Wells are located on gravel pads and are drilled vertically through approximately 2,000 feet of permafrost. Once through the permafrost, the bit is directed toward the desired bottom hole location. The number of wells per pad generally ranges from

16 to 40 (BP Exploration Alaska, Inc. and ARCO Alaska, Inc. 1997). The size of the pad and associated facilities is largely governed by the spacing between wells, and the number of pads is a function of the size of the area that can be drained by the wells on a pad. Historically, production wells were both straight or deviated holes and the number per pad was limited; hence, the number of pads needed to drain a specific area was high. The lateral reach of deviated holes rarely exceeded the true vertical depth of the well. New technologies have done much to increase the lateral reach of wells and to reduce the size and number of well pads.

The technologies developed over the last two decades have greatly reduced the size of the footprint left when developing an oil field. Wellheads may be much more closely spaced, far larger areas can be developed from a single small pad, the mud systems are less toxic, and reserve pits have been eliminated.

Coiled Tubing

The use of coiled tubing is particularly valuable in sensitive environments such as the North Slope. Coiled tubing technology is quieter and has far less impact on a drilling site than conventional equipment (U.S. Department of Energy 1999). The technology dates from the 1950s, but only after rapid technological advances in the late 1980s did it come into common use. The tubing is mounted on a large reel and is a continuous flexible coil that is fed into the hole. The use of coiled tubing does not require the repeated "tripping" out of the hole to add additional pipe segments. One of the byproducts of coiled tubing drilling is a significant reduction in the volumes of drilling fluids compared with conventional drilling. Coiled tubing mud volumes are commonly less than half those required or generated by conventional drilling practices. In many wells, conventional methods are used to drill the initial hole and then coiled tubing is utilized to drill horizontal segments or multilateral completions. The coiled tubing technology is also commonly used for slim-hole drilling (i.e., a rotary borehole of 5 inches or less, or a drill hole of the smallest practical size) and reentry projects.

The use of coiled tubing technology has substantial environmental advantages over the conventional drilling technology. The primary benefits include reduced mud volumes and drilling waste, cleaner operations, no connections to leak mud, reduced operations noise, minimized equipment footprints and easier site restoration, reduced fuel consumption and emissions, reduced risk of soil contamination due to increased well control, and better well-bore control. These advantages clearly support the use of coiled tubing whenever it is technically feasible. Many of the newer fields, such as the Alpine field, use this technology almost exclusively in conjunction with extended-reach horizontal drilling. No detrimental environmental effects are known to be associated with the introduction of coiled tubing technology to the North Slope.

Horizontal Drilling

Horizontal drilling became a reality in the 1970s due to advances in computers, steerable down-hole motor assemblies, and measurement (of rock properties)-while-drilling tools. A horizontal well is drilled from an initially vertical well-bore at an angle between 70 and 110 degrees. Vertical, or near vertical wells, drain oil from a single hole and have limited contact with the oil-bearing interval (usually limited to the vertical thickness of the rock unit). Horizontal wells penetrate the formation up to 5 miles or more from the vertical well bore, allowing more oil to drain into the well.

The results are a greater number of wells per pad, closer well spacing on the pad, and fewer well pads than using the old technology. Well spacing has decreased from 120 feet or more to as little as 10 to 15 feet between wells (BP Exploration Alaska, Inc., and ARCO Alaska, Inc. 1997). Pad size and radius of reach of the wells on the pad have undergone remarkable changes since the start-up of the Prudhoe Bay field in the 1970s.

The marked increase in drillable area per pad, as demonstrated at the Alpine field, is largely due to the extensive use of horizontal drilling technology. The environmental benefits include smaller footprints requiring less gravel and fewer wells to produce the same volume of hydrocarbons. These more effective drilling programs require less water (unless fracking is necessary) and consequently generate less drilling waste. Horizontal drilling results in smaller and fewer pads than did the older technologies, but gravel is still needed and effects on tundra and permafrost may result from gravel mining and emplacement. The closer spacing of well-bores has the potential to increase the rate at which permafrost thaw bulbs form, reducing surface stability and causing subsidence.

Multilateral Drilling

Multilateral drilling, a variant of the horizontal drilling technology, creates an interconnecting network of separate, pressure-isolated and reentry accessible horizontal or high-angle boreholes surrounding a single major borehole (U.S. Department of Energy 1999). Multilateral drilling is most effective in reservoirs that have isolated accumulations in multiple zones, have oil above the highest perforations, have lens shaped pay zones, are strongly directional, contain distinct sets of natural fractures, and are vertically segregated with low transmissibility.

The environmental benefits are similar to those achieved with horizontal drilling and include fewer drilling sites and smaller footprints, less drilling fluids and cuttings, and protection of sensitive habitats and wildlife. Multilateral drilling poses no additional recognized risks to the environment other than those associated with horizontal drilling.

Measurement-While-Drilling

Conventional down-hole logging practices consist of running a variety of remote sensing tools down a borehole prior to setting the surface casing, before any intermediate casing strings, and prior to completing the well at total depth. These tools are attached on wire-lines and are lowered into the uncased hole and pulled back to the surface. The tools record specific types of data as they are withdrawn from the hole. These data are then used to evaluate the rock type, reservoir properties, hole integrity, and the other features concerning the physical environment of the well-bore. The procedure is routine, but it can be a risky because irregularities in the hole can result in stuck or even lost tools. Conventional logging can be especially risky in a highly deviated or horizontal hole where there is an increased probability that the tool, while being pulled out of the hole, may become snagged on a resistant rock projection or become buried by loose debris collapsing into the hole.

Additionally, these important data are not available to the geologist until sometime after the well or interval has been drilled. This delay may vary from hours to days or even weeks. An example would be the desire to correlate the drilled section with that seen in a well some distance away, in order to predict a coring point or anticipate high-pressure sandstone.

Measurement-while-drilling technology can provide data virtually as the intervals are drilled. Additionally, sensors provide directional information and other key data that facilitate more effective geosteering and trajectory control (U.S. Department of Energy 1999). The recording sensors and other necessary equipment are housed in the drilling assembly at the bottom of the pipe-string, just a few feet above the drill bit.

Because of its real time capability, the measurement-while-drilling technology can be used to avoid formation damage by alerting the rig crew of problems before they become too serious to correct; similarly, there is a reduced possibility of blowouts and improved overall rig safety. This technology is also a contributing factor in the reduction of drilling waste volumes because it facilitates horizontal and multilateral drilling practices and provides better well-bore directional control. The technology also reduces the potential for loss of a wireline tool assembly, reducing waste and shortening the duration of the drilling process.

Light Automated Drilling System

As discussed earlier, the construction of ice roads and ice pads in remote areas requires an abundant water supply. There is legitimate concern regarding means of access in areas that lack sufficient water and/or fresh-water ice to build roads or if global climate change were to prevent the use of ice roads.

A possible solution to this problem, the light-automated drilling system, is in the research phase and is being considered for use on the North Slope. This potential drilling system is expected to be a lightweight drilling rig that can be easily broken down into several components and transported across tundra in winter by light impact vehicles that traverse natural snow cover but that would not require ice roads. This system, or others like it, could be adapted to work in areas that lack sufficient water for ice roads or during mild winters when it would not be possible to build an ice road, transport a rig to a drilling location(s), and return it to the staging area.

The principal benefit of a light-automated drilling system would be to reduce the need for water to build ice roads. The primary drawback from the environmental perspective would be the increased risk of damage to the tundra while transporting rigs between locations in the absence of adequate snow cover. The same concerns exist as are presently expressed for seismic activity, but on a much-reduced scale.

Development and Production

Production and associated operations are the longest-term activities in an oil field. The life of major oil fields on the North Slope could be expected to be about 30 to 40 years, occasionally as much as 50 years. During this time pipelines, production facilities, waste disposal systems, water treatment plants, injection facilities, road systems, and other specialized units continue to operate.

Industry attempts to produce the maximum amount of oil/gas at the least cost in order to maximize profits and to cope with oil price volatility. The most cost efficient technologies are the obvious choice of the operators. It is not surprising that in the early phases of development and production some of these choices have proven to be less than optimal from an environmental perspective. The use of reserve pits for the disposal of used drilling muds, cuttings, and other waste is one such example.

Today, on the North Slope, as fields continue to be discovered, developed, and produced, there continues to be the need for new pipelines, production facilities, waste disposal wells, etc. To reduce the environmental effects of these activities, new technologies have been developed or adapted for use on the North Slope. New methods do not eliminate the need for gravel, water, and other materials, but they reduce their use and cause fewer disturbances, therefore reducing the potential negative effects associated with wastes and road and pipeline construction.

Enhanced Oil Recovery

This technology involves the injection of formation/source water, natural gas, and miscible fluids into the producing reservoir to maximize recovery of hydrocarbons. In this process, not only is more oil recovered per well, but much of the wastewater associated with oil production is reintroduced into the reservoirs from which it was produced. Many problems that formerly were handled by surface or reserve-pit disposal techniques are solved.

The principal environmental benefits are greater recovery of oil without a proportionately greater number of wells and their associated waste, environmentally friendly disposal of produced water, and reduction of emissions that would be associated with the flaring of excess produced gas. Few negative environmental effects are associated with enhanced oil recovery. The primary concern is regarding spills of produced water.

Waste Disposal

From the 1940s to the 1980s, most well-associated wastes were either stored in reserve pits or handled through other surface disposal means such as incineration. The reserve pits were prone to seepage and spills, and they contained undesirable metals and volatile organic compounds. These did, and still do present environmental risk, especially at old, unclosed, remote exploration sites.

The reserve-pit closure program was instituted in 1996. To date, 50 percent of approximately 600 reserve pit sites have been closed. Down-hole disposal of wastes by injection into subsurface disposal intervals is utilized in all present-day exploration wells and producing fields. This mode of waste disposal is an effective and non-contaminating method of removing many unwanted materials from the surface environment. The grind-and-inject project was undertaken to dispose of the drilling muds and cuttings traditionally stored in reserve pits. Other wastes processed through the grind-and-inject plant include Class II (Resource Conservation and Recovery Act-exempt oily wastes) and drilling muds and cuttings from ongoing drilling operations.

Annular injection is an environmentally safe method of disposing of drilling muds and cuttings, and the injection of Class I and Class II materials into discrete disposal zones has provided a mechanism for the handling of produced formation waters and other associated wastes (National Research Council 2003). However, a large number of unclosed reserve pits remain at remote exploration well sites. No adequate plan is in effect to handle the possible pollution and resultant damage from poorly sealed and covered pits. The annular injection process has some potential to degrade existing casing or cement jobs in BLM Legacy wells and result in leakage to the surface. This has occurred on several occasions, but with no significant contamination of permafrost or surface. Worries regarding subsidence and marine contamination have been expressed, but the existing evidence indicates that subsidence is not a concern and disposal units are effectively and naturally isolated from any contact with the ocean or seafloor.

Gravel Use

Gravel in the area of Alaska north of the Brooks Range has been used for a variety of construction and maintenance purposes. These historical uses include construction of the following:

- Dalton Highway/Haul Road in support of the development of the North Slope oil fields and Trans-Alaska Pipeline System;
- Pads for camps, exploration drilling, development and production drilling sites, and operations and maintenance facilities;
- Airports in oil field areas and in the communities of the North Slope Borough;
- Roads in oil field areas and in the communities of the North Slope Borough;
- Man-made islands for offshore exploration drilling and for development and production facilities;
- Docks and causeways; and
- Beach nourishment in several of the North Slope Borough communities.

From 1974 to 1999, more than 205 million tons of gravel was mined to meet the industrial and community construction and maintenance needs in the Northern Region that includes the Brooks Range, the area north of the Brooks Range to the Beaufort Sea coast (the North Slope), the Chukchi Sea coast north of Cape Krusenstern, and North Slope Borough communities (National Research Council 2003). Most of the gravel was mined from the floodplains of rivers. About 180 million tons of the gravel (88 percent of the total) was mined from 1974 to 1985. During this time, the Haul Road/Dalton Highway and pads, roads, and airfields were constructed for the facilities to develop the Prudhoe Bay, Kuparuk River, Lisburne, Milne Point, and Endicott oil fields. From 1986 to 1999, the amount of gravel mined annually in the Northern Region ranged from 0.56 to 4.5 million tons.

The portion of the oil-field network that is connected by roads stretches 60 miles from the Endicott field in the east to the Tam oil field in the west. Most of the expansion of the road network was done before 1988, the development phase in the Prudhoe-area fields, during which the rate of growth was about 24 miles per year. Since 1988, the rate of growth in the road network has been about 3 miles per year (National Research Council 2003).

The total gravel-covered area increased from about 20 acres in 1968 to about 9,000 acres in 2001 (National Research Council 2003) The rate of gravel placement declined noticeably after 1988, because the main road network and most of the pads in the Prudhoe Bay and Kuparuk oil fields had already been built. The average rate of growth was 300 acres per year before 1988 and 42 acres per year after 1988. Most of the gravel-covered areas are associated with onshore drilling and construction pads.

Offshore gravel islands support production operations. The Endicott islands are connected to each other and to the mainland by a 5-mile causeway and are situated in waters generally less than 7 feet deep (Alaska Oil and Gas Association 2001). The shallowness of the Beaufort Sea in the Prudhoe Bay prevents large vessels from docking there. Three gravel causeways were constructed to facilitate docking, to provide access to artificial-gravel production islands, and to draw seawater for waterflooding.

The Alaska Department of Fish and Game, Habitat and Restoration Division, developed guidelines for siting, design, operation, and reclamation of North Slope gravel pits. The area disturbed by gravel mines and fill placement is a very small fraction of the Arctic Coastal Plain north of the Brooks Range. The North Slope covers about 57 million acres, and the Arctic Coastal Plain covers about 13 million acres (Gilders and Cronin 2000). The cumulative area that would be disturbed by gravel mines and fill placement, assuming construction of Alpine satellites CD-5, CD-6 and CD-7 is projected to rise to 18,680 acres, or about 0.14 percent of the Arctic Coastal Plain (Table 4-41).

Table 4-41. Industrial disturbed areas on the North Slope, 1968 to 2001 (in acres)

Disturbed areas	1968	1973	1977	1983	1988	1994	2001
Gravel footprint areas	20	1,714	3,240	6,940	8,446	8,690	8,998
Other impacted areas[1]	308	1,388	1,552	1,694	1,698	1,762	1,765
Gravel mines	25	4,766	5,146	5,756	6,241	6,247	6,364
Dalton Highway	0	0	564	564	564	564	564
Total disturbed area	917	8,432	10,502	14,954	16,949	17,263	17,691

1. Disturbed area around gravel pad, peat roads, tractor trails, exploration roads, gravel pad removal site, etc.
Dalton Highway based on width of 28 feet for 166 miles on North Slope.
Source: National Research Council 2003

Surface deposits within the NPR-A consist mostly of fine-grain clay, silt, and sand. Gravel is located along the slopes of the Brooks Range, the Colville River, and some scattered areas along the Arctic coast. West of the Colville River, gravel sources become increasingly sparse because of the low-relief, poorly drained character of the Arctic Coastal Plain. Meandering rivers have low energy and a low capability of transporting coarse clastic material (gravel) from higher elevations. The Brooks Range is far from the coast on the western North Slope and the Colville River drainage has captured most of the sediment shed north from the Brooks Range. Consequently, suitable gravel sources are far more difficult to locate. Because long hauls are often required to bring in gravel, gravel from existing work/drill sites is reused (Gryc 1985). This lack of gravel would be an important consideration in the development of permanent oil and gas facilities west of the Colville River. Although there are no specific proposals, there is ongoing discussion about the potential need for inter-community roads west of the Colville River. Such roads would also require large amounts of fill material (gravel and sand), since gravel roads require 60,000 cubic yards per mile. (For the purpose of this IAP/EIS, the envisioned community road network is not considered reasonably foreseeable).

In general, North Slope gravel usage for oil fields has been declining. Large fields (such as Prudhoe Bay and Kuparuk) that require a large number of production well pads are no longer being discovered. There also is a trend toward consolidating facilities and using technological advances that minimize the surface area disturbed (Gilders and Cronin 2000). Overall, the footprint of oil fields is getting progressively smaller because wells are spaced closer together and on-pad structures are minimized. A smaller footprint equates to less gravel use.

Other developments that have reduced the amount of gravel needed to develop or maintain oil and gas production facilities have utilized the following practices:

- Use of ice pads instead of gravel for exploratory well-drilling pads (onshore and offshore in shallow waters, where appropriate);
- Use of mobile steel or concrete bottom-founded structures to drill exploratory wells in shallow waters;
- Use of ice roads instead of gravel roads for pipeline construction;
- Development of fields without a gravel road connection to the Prudhoe Bay/Deadhorse area (e.g., Badami and Alpine fields);
- Reduction of the spacing distance between development wells, which reduces the size of the development pads;
- Use of extended-reach drilling, which reduces the amount of gravel needed to develop new reservoirs that lie near established facilities;
- Recycling of gravel from roads, airfields, or pads that are no longer used; and
- Use of clean drill cuttings in place of gravel.

Future oil field development would be based on refined variants of the Alpine model. Pads would be small and few in number and construction would be largely a winter activity with transportation via ice roads. The use of gravel would be appreciably reduced but would likely still be necessary to connect satellite developments with the larger pads that contain housing, airstrip, and the production facility.

Pipeline Construction and Spill Prevention

Among the standard practices utilized in the construction of pipelines are gravel maintenance and construction roads, elevated river crossings, and block valves to reduce the likelihood and sizes of leaks and spills. Innovative construction techniques have lessened the environmental effects of pipeline construction, the hazards to the pipeline due to flooding, the probability and severity of leaks, and impediments to caribou movement. These new approaches were all used in the design and construction of the Alpine field oil pipeline (Lance 2000), which was built largely during the winter using ice roads. The lack of a gravel maintenance road removes one potential barrier to caribou movement, and reduces the volumes of gravel required for the Alpine field-like projects and the amount of tundra impacted by burial.

The Colville River pipeline crossing posed a considerable challenge. During breakup and the associated flooding, the river is almost 2,600 feet wide and could destroy an above ground pipeline or erode deeply enough to expose and rupture a line buried in a surface trench. ARCO Alaska, Inc., elected to use horizontal directional drilling to position the pipeline deep beneath the river channel (Lance 2000). More than 4,000 feet of pipeline were placed 100 feet below the river.

After conducting an oil-spill isolation strategy study that reviewed ways of meeting federal leak-containment regulations, ARCO Alaska, Inc., elected to use 39 to 46 feet high vertical loops on the Alpine field pipeline in lieu of the more conventional block valves. The study concluded that when used in tandem with emergency pressure-letdown valves or divert valves, vertical loops would contain drain-down-related spills as well as block valves, while offering operations and maintenance efficiencies (Pavlas et al. 2000).

The loops are better than manual block valves for reducing catastrophic failures and they provide protection levels similar to those achieved by remotely actuated valves for leaks of all sizes. They are not potential leak sites, as valves are, but they do not provide any substantial benefit over block valves for pinhole leaks. With approval from the Department of Transportation, the loops were placed at river crossings and high points along the line.

These new pipeline construction methods greatly reduce the environmental effects on tundra, provide for a safer line, and lessen the probability of spillage due to river-induced pipeline damage. They also more effectively limit the size of catastrophic spills. However, the placement of a pipeline at depth beneath a river could make detection and cleanup of a spill in the buried segment difficult. The preexisting and predominant North Slope pipeline technology presents impediments to caribou movement when in close proximity to roads, and river crossings are sites of potential severe environmental consequences if a spill occurs. The accumulation of effects of continued construction of pipelines and road systems could increase the magnitude of displacement of the calving caribou away from the coastal strip and prime forage/insect-relief areas.

Remote Sensing

Remote-sensing techniques such as infrared photography have been used to design and locate ice roads, ice pads, and development facilities, to reduce effects on the environment. Satellite infrared photography has been utilized to facilitate habitat mapping in the Alpine field (Lance 2000). The environmental benefits come from the avoidance of critical habitat and better design of facilities that must be placed within less than ideal locations.

Abandonment and Reclamation

The factors leading to a decision to abandon a field can differ for each field, but declining production rates and oil price are usually the two key considerations. Abandonment occurs when the field is no longer economically viable.

To date, very little abandonment (except for single exploration or development wells) has occurred anywhere on the North Slope. According to the U.S. General Accounting Office (GAO 2002), as of December 2001, no production pads have been abandoned, as all of the production wells associated with the pad must first be plugged and abandoned, which has not taken place. Restoration of other types of facilities, such as gravel extraction sites and older exploration pads has taken place at a small scale at several locations on State lands on the North Slope outside of the NPR-A planning area (Jorgenson et al. 1992, McKendrick et al. 1992, Herlugson et al. 1996, McKendrick 1996). These restoration efforts are being closely monitored in an effort to determine the most appropriate and effective methods for successful restoration.

Aging infrastructure increases the likelihood of failure, which can lead to accidental discharges (spills) or to other accidents. Abandoned roads and other structures can degrade from melting permafrost and continue to alter the visual environment, especially if the climate continues to warm.

Most North Slope oil-field equipment dates from the last quarter of the 20th century. Pipelines could fail through corrosion, subsurface safety valves, and safety systems to suppress fires and explosions. The older oil-field areas, such as Prudhoe Bay, will be most susceptible to aging. Thus, age-related investments demands will increase as oil revenues from declining oil fields decrease. As an aging field's production declines and the cost of extracting smaller quantities of oil increases, the economic incentive to postpone or eliminate maintenance and replacement will increase. The environmental effects of aging infrastructure will depend on interactions between the economics of declining fields, increased replacement and maintenance costs, the regulatory regime, and other factors equally hard to predict.

The oil industry and many public landowners use the term DR&R, to refer to dismantlement and removal of infrastructure and restoration of the land following removal activities. The DR&R can range from complete restoration to a natural state approaching original condition to simply removing structures (GAO 2002).

The State of Alaska has adopted general DR&R requirements that contain no specific stipulations on what infrastructure must be removed or to what condition the lands must be restored once oil production ceases (GAO 2002). The State specifies that oil companies must return the land to the condition that is satisfactory to the State, a condition that has not been defined. Other entities, such as the Army Corps of Engineers, North Slope Borough, and Native landowners, have the authority to impose DR&R requirements, but generally defer to the State to impose these requirements. Under existing funding mechanisms, only a small portion of the funds are presently reserved to dismantle, remove, and restore oil and gas facilities. The State of Alaska requires companies to post bonds or other forms of financial assurance as a condition for obtaining a lease and drilling permits. However, companies are required to maintain only $500,000 in assurances to cover all of their leases in the State; it is estimated that it will cost billions of dollars to conduct DR&R for existing infrastructure on the North Slope.

The BLM's overall restoration goal for the NPR-A is to return it to its original condition, which includes fish and wildlife habitat, after oil production ceases; however, the BLM has yet to develop specific DR&R requirements for companies to use. On the other hand, the

Bureau of Energy Management has specific DR&R requirements for offshore drilling. The Bureau of Energy Management has an escalating bond structure that considers, among other things, the future costs of reclamation, increasing the likelihood that future DR&R costs would be covered by the bond. Both agencies have the authority to require financial assurances to fund DR&R.

By the terms of Federal and State leases and permits, it is the responsibility of the lessee/applicant to remove facilities and reclaim the land upon field abandonment or expiration of a lease or oil and gas-related permit to the satisfaction of the land management authority (Lease Stipulation G-1). Abandonment plans would be developed at the time of abandonment or expiration of the lease or permit, in consultation with appropriate local, state, and Federal agencies, and would be subject to Federal (BLM, Army Corps of Engineers, and/or EPA) and State approval. Federal agencies would undertake appropriate National Environmental Policy Act analysis of any such abandonment and reclamation decision at the time of abandonment or expiration of a lease or permit. All costs associated with abandonment, removal, and restoration are the responsibility of the lessee.

The authorized officer may require any range of abandonment and reclamation steps for roads. For gravel roads, these steps could include: 1) leaving roads in place and maintained for continued use; 2) revegetating roads either naturally or actively by the permittee, removing bridges and culverts, and breaching roads to facilitate more natural water flow; or 3) removing roads, with gravel either being placed back into gravel pits or reused for other development in the area.

Abandonment of the proposed pipelines could include demolition and removal of the facilities and restoration of disturbed ground. It is anticipated that pipeline removal would be consistent with that described for the Trans-Alaska Pipeline System in the Trans-Alaska Pipeline System Right-of-Way (ROW) Renewal EIS. Based on the Trans-Alaska Pipeline System, it is assumed that abandonment could include the following:

- All aboveground pipelines, valves, and supporting structures would be removed to a depth that would prevent frost heave action lifting the remnant to the surface.
- Any below-ground pipeline segments would be cleared, cleaned of oil and other residues, capped, and left in place in locations where they would not interfere with other abandonment activities or planned land uses.
- Central production facilities would be used as work camps and staging areas to support pipeline abandonment activities.
- Residual, surplus, and scrap materials would be reused or recycled to the extent possible, and waste materials would be disposed of in accordance with applicable regulations.

It is assumed that aboveground facilities would be removed and wells plugged and capped. Equipment could be retrofitted for other North Slope use, or removed from the North Slope for subsequent reuse or scrap. Just as with roads, the ultimate fate of the gravel pad would not be known until closer to end of the production pad life. Permitting agencies could require that gravel be removed, in part or total, and the tundra revegetated. If other uses are determined by the permitting agencies to be preferable, the agencies could allow the permittee to leave the gravel pads in place, either revegetated or not revegetated. Removed gravel either would be disposed of or reused for another development.

Abandonment of airstrips could occur in conjunction with abandonment of pads. The gravel airstrips would be managed in a similar manner, depending on the decisions made by land managers and permitting agencies at the time of abandonment. Gravel airstrips would either be removed and the tundra revegetated, revegetated but otherwise left in place, or left in place and maintained for public use.

As with roads, abandonment of bridges and culverts would occur once the economic life of the oil fields had passed. Because the bridges and culverts are an integral portion of the proposed road network, the fate of the bridges would likely be determined by the fate of the road network. If bridges were removed, bridge superstructures would be taken apart and transported out of the area for recycling or disposal of the materials. Bridge piles likely would be cut off below the lowest anticipated scouring elevation from either natural scouring or a flood-induced event. The area of bridge abutments would be revegetated in a manner similar to that of the roadbed after gravel removal. If roads were left in place, but not with the intention that they be maintained for continued use, culverts could be removed and the gravel pads breached to facilitate water flow.

Abandonment activities would occur during winter months, when ice roads could be constructed to allow the removal of equipment. Overall, abandonment operations would take many years, as revegetation and environmental monitoring studies would continue to document the long-term effects of operations at a particular site. Monitoring abandonment would require periodic revisits to gather information on environmental parameters related to natural bedding and to document the success of abandonment actions. Normally, one helicopter with a crew of three would visit the sites annually for the first 5 years, followed by visits with increasing time gaps over the next 10 years. Site visits would include a maximum of 1 day per visit, and one visit per year. A series of permitting and inspection activities would be associated with any oil field abandonment, and would involve visiting the site as needed until satisfactory revegetation occurred.

Technical and Natural Constraints to Reclamation

The North Slope presents special technical challenges to restoration and recovery. Extremely cold temperatures, meager precipitation (5 to 7 inches per year), and the short growing season lengthen recovery times substantially beyond those possible elsewhere in the United States. Natural recovery of disturbed sites to original soil and plant conditions has been estimated to require 600 to 800 years for upland sites and 100 to 200 years for marsh sites (Alaska Oil and Gas Association 2001).

Recovery of disturbed sites on the North Slope is complicated by the fact that any disturbance of the insulating vegetative mat can melt the underlying permafrost, a process that is extremely difficult to reverse and that can continue long after the initial disturbance ends. Finally, gravel pads and roads, which account for the vast majority of the directly affected habitat on the North Slope, retain moisture and nutrients poorly and thus slow recovery processes.

Recovery times in the Arctic, as elsewhere, depend in part on the nature and extent of disturbance and the type of habitat affected. For example, wet sites tend to recover quickly from light oil spills; dry sites affected by diesel fuel spills recover exceedingly slowly, with little recovery occurring after several decades (Walker 1996). Disturbed areas that would recover relatively quickly in more temperate climates (such as those caused by Caterpillar tractor tracks), can persist for many decades because of melted permafrost.

Reclamation Research

During the past few decades, considerable industry research has examined the feasibility of rehabilitating areas disturbed by oil field activities (McKendrick 1997). Until recently, work focused on revegetating sites with exotic grasses to avert erosion. More recent efforts have focused on the use of native grasses and forbs and on the restoration of habitat processes and aesthetics, all of which are much more challenging goals (Alaska Oil and Gas Association 2001).

A variety of rehabilitation strategies has been developed, including flooding of gravel mine sites to create overwintering habitat for fish; creation of wetlands in ponds perched on overburden stockpiles; revegetation of thick gravel fill and overburden to compensate for lost wildlife habitat; removal of gravel fill to help restore wet tundra habitats; restoration of tundra on less severely modified habitat; and remediation of areas contaminated by oil spills, seawater spills, and drilling mud (Jorgenson and Joyce 1994). The oil industry is conducting experiments at several sites throughout the Prudhoe Bay oil field and at old well sites in the NPR-A. Preliminary results indicate that, if cost is not a factor, a productive and diverse vegetative cover can be established even on sites with severe ecological limitations. Most of the studies suggest that natural recolonization occurs relatively rapidly on thin fill and on organic rich fill where moisture and nutrients are not severely limiting (Jorgenson 1997). Low temperatures near the coast, however, reduce the number of species available and the rate at which recolonization occurs. A survey of 12 revegetated pads in the NPR-A showed that, on average, only 3 native species were found on pads at the cold coastal sites, 10 were found on inland coastal plain pads, and 24 were found on relatively warm foothills sites (McKendrick 1987). Fertilization and seeding with normative species appears to delay natural recolonization (Jorgenson 1997).

More costly methods are required for rehabilitating the gravel roads, pads, and mine sites that dominate disturbed land. Construction of berms and basins, application of topsoil, and use of various plant cultivation techniques are required on these sites. However, only a very limited amount of topsoil has been stockpiled for future use in the oilfields (Jorgenson 1997). Sewage sludge is being considered as an alternative source of organic material. Native legumes with nitrogen-fixing ability could be essential for sustaining the long-term productivity of those sites.

Removal of gravel fill has recently been done in wetlands, and preliminary studies suggest that wetland mosaics of vegetation can be restored, if only partially, although the method is expensive and finding acceptable locations for the fill can be difficult (Kidd et al. 2004).

Open-pit gravel mine rehabilitation typically involves converting mine sites (generally, pits along gravelly streams) to lakes, with a channel usually cut between the pit and a stream or river so the site can be accessible to fish. Such sites create potential overwintering habitat for fish, but they also result in the permanent loss of the original habitats.

4.8.4 Cumulative Oil Spills

An important element in estimating environmental impacts associated with oil and gas activities on the North Slope is potential accidental large oil spills. Oil production has occurred on the North Slope since the mid-1970s. Accidental spills of crude oil have occurred on the North Slope due to oil and gas exploration and production (National Research Council 2003). The average volume of crude oil spilled annually to 2000 from the Alaska North Slope operations and the Trans-Alaska Pipeline System segment from Pump Station 1 to Atigun Pass is 523 barrels of crude oil and 278 barrels of product (Niebo, pers. comm., as cited by National Research Council 2003). Environmental effects of small spills are generally less significant than large spills because they typically occur on pads or roads and are contained and cleaned up at the site of the spill. Therefore, small spills are less likely to cause adverse environmental effects (National Research Council 2003). The largest 10 percent of Alaska North Slope crude spills to 2000 accounted for 87 percent of the volume spilled (National Research Council, 2003). For purposes of analysis of cumulative oil spills, the discussion below focuses on large crude oil spills.

The history of Alaska North Slope large volume crude spills is discussed to set the framework of previous large oil spills from oil and gas production. Generally, the frequency of large oil spills is decreasing through time as both regulation and technology have been able to address the causal factors of past large oil spills (Schmidt-Etkin, 2011). Between 1985 and 2010 there were eight crude oil spills of 500 or more barrels onshore on the North Slope while producing 12.4 billion barrels. One of these spills was greater than or equal to 1,000 barrels. That was the GC-2 spill of 2006 in which 5,054 barrels leaked from a BP pipeline. The total volume of these large spills was approximately 9,800 barrels. No large (greater than or equal to 500 barrels) offshore U.S. Arctic (State and Federal) spills from oil and gas exploration and production have occurred to date. One large spill of diesel heating fuel (1,619 barrels), from a punctured fuel barge, occurred north of Flaxman Island in the Beaufort Sea on August 20, 1988 but was not related to the oil and gas industry. Nine large Trans-Alaska Pipeline System pipeline oil spills (greater than or equal to 500 barrels) have occurred from 1977-2010 while transporting 16.28 billion barrels. The total volume of the nine large Trans-Alaska Pipeline System spills was approximately 46,000 barrels, using the high spill volume estimates, with three of those spills occurring on the Alaska North Slope totaling approximately 11,400 barrels.

To estimate the assumed number of large oil spills for the analysis of cumulative effects, BLM used a production estimate. The production estimate includes past, present, and future production for the Alaska North Slope and Beaufort and Chukchi seas. For cumulative case analysis, estimates are made for past, present and future production for the Alaska North Slope and adjacent Outer Continental Shelf areas in the Beaufort and Chukchi seas. The estimates for past activities include remaining proven reserves in already developed fields. The estimates for present activities include proven and probable resources reported for discovered fields expected to be developed in the near future. The estimates for future activities are based on undiscovered resources that may become future commercial projects under favorable conditions. All of these scenarios are predicated on high oil/gas prices (above $60), stable tax policies, continued operation of key infrastructure

(Trans-Alaska Pipeline System), and no regulatory impediments or legal delays. Estimates for future production are much more uncertain because the fields have not been discovered and the above economic factors cannot be guaranteed for decades into the future

To determine an assumed number of large oil spills for purposes of cumulative analysis the estimated production volumes were multiplied by the appropriate large spill occurrence rate per billion barrels produced (Table 4-42). For further details on large spill occurrence rates for the Alaska North Slope, Outer Continental Shelf, and Trans-Alaska Pipeline System pipeline, please see Appendix G. For the NPR-A, all the alternatives are shown in Table 4-42 but only the Alternative D production estimates are used for purposes of estimating large spill numbers for the cumulative analysis because, while all the NPR-A alternatives have the same assumed number of large spills, Alternative D would produce the most oil from the NPR-A. For further information about the estimated mean spill number and assumed number of large spills for each NPR-A alternative, see section 4.2.2 (Volume 2).

The incremental NPR-A Alternative D contribution by number of large spills is about 6-13 percent of the cumulative case total estimate. All alternatives (A-D) contribute equally based on the incremental contribution of assumed large spills, which is rounded up to one for all alternatives. The alternatives vary in their incremental contribution by production. Alternatives A and C contribute 6-11 or 12 percent, respectively, Alternatives B-1 and B-2 contribute 4-9 percent, and Alternative D contributes 7-13 percent to the cumulative case total production estimate.

The estimated Colville Canning/State Beaufort Sea large spills could occur either in the offshore state waters of the Beaufort Sea or onshore from facilities and pipelines between the Colville and Canning River. Future discoveries of unconventional oil from shale gas or increased production of heavy oil are not included in the Colville Canning/State Beaufort Sea estimates.

The Bureau of Ocean Energy Management (2012; Table 4.6.1-4) estimated 2 Outer Continental Shelf platform/rig large spills could occur in offshore Outer Continental Shelf water depending upon a price assumption of $160 per barrel. For purposes of analysis, BLM used the higher end of the estimated resource range of $160. The estimated six Arctic Outer Continental Shelf pipeline large spills could occur either onshore or offshore. For purposes of analysis, the estimated large Outer Continental Shelf pipeline spills were allocated equally to offshore and onshore. For the three estimated onshore spills, it is assumed that two large pipeline spills could occur along a 300-mile onshore pipeline traversing the NPR-A and other western North Slope lands from the Chukchi Sea to the Trans-Alaska Pipeline System Pump Station 1. One onshore pipeline spill could occur in the Colville to Canning area from Outer Continental Shelf production in the Beaufort Sea.

The estimated six large Trans-Alaska Pipeline System spills includes all large spills that could occur over the entire length of the pipeline, pump stations, and associated tank farms. For purposes of analysis, two of the spills were assigned to the North Slope based on the historical geographical location of large Trans-Alaska pipeline spills. The other four spills were assigned to the rest of the geographic extent of the Trans-Alaska pipeline.

Table 4-42. NPR-A cumulative large oil-spill-occurrence estimates resulting from future oil production, 2012-2100

Category	Large Crude Oil Spills				
	Reserves and Resources (Bbbl)	Spill Rate[1] (spills/Bbbl)	Size Category (bbl)	Assumed Size (bbl) Pipeline/Facility[2]	Assumed Number of Large Spills for Analysis
NPR-A					
Alternative A	0.723	0.65	≥ 500	5,100/900	1
Alternative B-1	0.505	0.65	≥ 500	5,100/900	1
Alternative B-2	0.549	0.65	≥ 500	5,100/900	1
Alternative C	0.707	0.65	≥ 500	5,100/900	1
Alternative D[3]	0.761	0.65	≥ 500	5,100/900	1
Colville Canning/State Beaufort Sea	3.15	0.65	≥ 500	700/700	2
Arctic OCS (Beaufort and Chukchi Sea)[4]	7.33	1.13[5]	≥ 1,000	1,700/5,100	8[6]
TAPS Pipeline	11.24	0.55	≥ 500	4,000/NA	6[7]
Total[1]	11.24	-	-	-	17

1. Large spill occurrence rates for Alaska North Slope, Outer Continental Shelf and the Trans-Alaska Pipeline System (TAPS) are discussed in Appendix G. Bbbl = billion barrels
2. The first number is the assumed pipeline spill size and the second number is the assumed facility size. The highest pipeline or facility spill size in the Alaska North Slope spill record is used for the NPR-A assumed large spill size. All other assumed large spill sizes are median spill sizes.
3. For purposes of analysis, the BLM uses Alternative D for the summation of the total estimated production.
4. The reserves, resources, and large spill numbers assume an oil price of $160/barrel. At a price of $60/barrel, Bureau of Ocean Energy Management estimates the reserves and resources at 2.00 billion barrels and two large spills (USDOI Bureau of Ocean Energy Management 2012).
5. The assumed number of large spills is from USDOI, Bureau of Ocean Energy Management (2011). It is estimated using the 1996-2010 spill rates in Anderson, Mayes and LaBelle (2012). For the Arctic Outer Continental Shelf, the 1996-2010 spill rates were compared to fault-tree rates in Bercha Group Inc. (2008 a, b, 2006). The greater number of estimated spills from Anderson, Mayes and LaBelle (2012) is represented in the table. The Anderson, Mayes and LaBelle (2012) spill rate is about twice the spill rate as Bercha Group Inc. (2008 a, b, 2006).
6. The values provided for the Arctic Outer Continental Shelf are the combined totals for the Beaufort and Chukchi Seas. For purposes of analysis, three Outer Continental Shelf large pipeline spills are assumed to occur onshore. Of those, two spills could occur from a large diameter common carrier pipeline from the Chukchi Sea across the western North Slope to the Trans-Alaska Pipeline System and one onshore spill between the Colville and Canning Rivers from Outer Continental Shelf production in the Beaufort Sea.
7. The estimated large Trans-Alaska Pipeline System pipeline spills include spills from the pipeline, pump stations, and associated tank farms and could occur along the entire length of the Trans-Alaska Pipeline System. Of those spills, two could occur on the North Slope and four along the rest of the pipeline length.

4.8.5 Resource Protection Measures Considered in the Cumulative Effects Analysis

The cumulative impacts assessment assumes that required operating procedures/best management practices and lease stipulations developed for the alternatives (see Table 2-2 in Volume 1) would be adopted to protect environmental and social resources in the planning area. The effectiveness of these protections has been addressed under each resource area for each alternative in sections 4.3 through 4.6 (Volumes 2 and 3), and in Table 2-2 (Volume 1).

In addition, a number of federal, State, North Slope Borough, and Alaska Native resource management and monitoring programs have been established to protect environmental resources and, in cases where there is existing environmental impairment, to effect restoration. The assessment of cumulative impacts must recognize the existence of these programs and assume that the mandate under which each program was established will continue. The practical effect of these programs is that they are assumed to require avoidance or mitigation of the environmental impacts that they are designed to address. The programs assumed to continue for the cumulative impact assessment are described by the resource that they manage or protect in the following sections.

4.8.5.1 Air Quality

Air quality on the North Slope is regulated under the Federal Clean Air Act, as implemented by the State of Alaska, Department of Environmental Conservation, Division of Air Quality, with oversight by EPA Region 10. In addition, Alaska Department of Environmental Conservation may establish regulations which are more (but not less) stringent than the Federal requirements. Under both the Clean Air Act and Federal Land Policy and Management Act, the BLM may not conduct or authorize activities that do not comply with all applicable local, State, tribal, and federal air quality laws, regulations, standards, and implementation plans. Climate activities focus on monitoring observed conditions and predicting potential changes due to global increases in greenhouse gases. The State climatologist is located at the Alaska State Climate Center on the University of Alaska campus in Fairbanks. Currently, there are no regulations applicable to climate or climate change, although there is much discussion regarding potential limits of fossil carbon emissions.

4.8.5.2 Water Quality

Water quality on the North Slope is regulated and/or monitored through various permitting and regulatory programs administered by the EPA, Alaska Department of Natural Resources, Alaska Department of Environmental Conservation, Alaska Department of Fish and Game, and North Slope Borough. These programs have been established to protect against the significant degradation of water quality associated with specific human and development activities. In evaluating the cumulative effects to water quality, collective impacts associated with regulated and nonregulated activities, and naturally occurring events are considered.

4.8.5.3 Wetlands and Floodplains

Wetland impacts are mitigated through Section 404 of the Clean Water Act, administered by the Army Corps of Engineers. The objective of mitigation for unavoidable impacts is to offset environmental losses. In 2008, the United States Army Corps of Engineers (Corps) and the Environmental Protection Agency (EPA) published a new rule, entitled “Compensatory Mitigation for Losses of Aquatic Resources; Final Rule.” The rule emphasizes the sequence to be followed for mitigating impacts to aquatic resources that result from work authorized by permit under the Corps Regulatory Program. All practicable steps to avoid and/or minimize impacts to aquatic resources must be taken before proposing compensatory mitigation to offset project impacts. The rule establishes standards and criteria for all types of compensatory mitigation, including mitigation banks, in-lieu fee (ILF) mitigation, and permittee responsible mitigation, to offset authorized unavoidable impacts to waters of the United States (U.S.), including wetlands

4.8.5.4 Fish

The amended Magnuson-Stevens Act requires federal agencies that authorize, fund, or conduct activities that may adversely affect Essential Fish Habitat to work with the NOAA Fisheries Service to develop conservation recommendations that minimize adverse effects to Essential Fish Habitat. By providing essential fish habitat conservation recommendations before an activity begins, NOAA Fisheries Service may help prevent habitat damage before it occurs, rather than restoring habitat after the fact, which is less efficient, unpredictable, and often more costly.

Further safeguards for fish and fish habitat are in place by the State of Alaska. Both the Fishway Act and Anadromous Fish Act mandate that freshwater habitat for resident and anadromous fish be protected by the State. These are partly implemented through the evaluation process involved in Fish Habitat Permits issued by the Alaska Department of Fish and Game.

4.8.5.5 Caribou

The Alaska Department of Fish and Game, North Slope Borough and the BLM monitor caribou by population censuses; calving, composition and yearling survival surveys; and caribou movement and distribution studies. These monitoring efforts provide a means of determining whether cumulative effects on caribou have occurred, or are occurring, on the North Slope, and help in developing measures to minimize effects.

4.8.5.6 Marine Mammals

The management of seals by NOAA Fisheries Service and polar bears by the U.S. Fish and Wildlife Service under the Marine Mammal Protection Act of 1972 provides for protecting these species' populations and mitigating the potential effects of development on these species. For example, the U.S. Fish and Wildlife Service implements measures to protect polar bear den sites through a Letter of Authorization under the Marine Mammal Protection Act.

4.8.5.7 Threatened and Endangered Species

The potential effects from all federal actions on listed species would be identified and potential mitigation offered by NOAA Fisheries Service and the U.S. Fish and Wildlife Service as required by Section 7 of the Endangered Species Act.

4.8.5.8 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," and an accompanying Presidential memorandum require each federal agency to make the consideration of environmental justice part of its mission. The existing demographics (race and income) and subsistence consumption of fish and game would be discussed, disproportionate environmental and health effects on Alaska Natives would be evaluated, and mitigating measures and their effects would be presented in any EIS considering federal actions.

4.8.5.9 Consultation and Coordination with Indian Tribal Governments

Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments," requires consultation with Native tribal governments on "actions that have substantial direct effects on one or more Indian tribes." Future federal actions will also be subject to this procedure that would ensure tribal concerns are heard.

4.8.6 Other Information Considered in Cumulative Effects Analysis

The assessment of cumulative impacts from oil and gas activities also considered the following information:

- More rigorous environmental standards and more environmentally prudent industry practices exist than ever before, including smaller facility footprints, fewer roads, directional drilling, elimination of most surface discharges into the water, practices that avoid damage to the tundra, and better working relations with the local residents.
- Current industry practices and the environmental state of the North Slope/Beaufort Sea region are continually observed and assessed, and much of this information is available to the public. This information, along with the ongoing dialogue between all levels of government and the interested public about environmental issues should continue to increase environmental awareness and encourage environmentally sound practices that, in turn, help reduce the potential for environmental damage.
- A key element in the development of North Slope/Beaufort Sea oil is the means of transporting the oil to outside markets through the Trans-Alaska Pipeline System. The Trans-Alaska pipeline is 800 miles long, stretching from Pump Station 1 at Prudhoe Bay to the Valdez Marine Terminal. Assuming a corridor width of about 100 feet, it represents an area of about 16 square miles. This pipeline is expected to continue to serve as infrastructure for all oil production in the foreseeable future, eliminating the need for the construction of new oil pipelines other than feeder pipelines.
- Following the Exxon Valdez oil spill, substantive improvements have been made in tanker safety to reduce the potential for oil spills from tanker accidents, such as a mandatory phase-in of double-hulled tankers, better navigational systems, and tanker escorts. In addition, oil spill response capabilities for tanker-related oil spills have been increased substantially through the addition of equipment, personnel, training, and exercises. These initiatives were developed specifically to reduce the potential for future tanker accidents and to lessen their effects, should spills occur.
- If a large oil spill were to occur, such as occurred on the North Slope in March 2006, additional safeguards would likely be put in place, and new ideas of pipeline placement and design would be researched. With these safeguards in place, the likelihood of an additional oil spill occurring from the same causative

factors and impacting the same resources would be reduced. This emphasis on preventing a similar incident would further ensure the full recovery of those resources from the initial spill.

- Actual activities and the size and location of future oil and gas developments on the North Slope and in the Beaufort and Chukchi seas are uncertain; this IAP/EIS presents a best estimate of what those activities and effects would be. It is unlikely that actual activities and effects would exactly match the scenarios developed for this IAP/EIS. Most past efforts to foresee future northern Alaska activities have over-stated the level of those activities in the projected scenario. Effective corrective measures have come out of ongoing monitoring by industry, government, and environmental groups. Subsequent discoveries and developments and other changes not accounted for in this scenario may need to be reassessed, as appropriate and as required by the National Environmental Policy Act.

4.8.7 Cumulative Effects on the Environment

4.8.7.1 Air Quality and Climate

This section qualitatively describes the potential cumulative air quality and climate impacts associated with the IAP.

Cumulative air quality impacts may result from the emissions of fugitive dust (particulate matter [PM]), byproducts of combustion (carbon monoxide, nitrous oxides, and sulfur dioxide), and evaporation of hydrocarbons. These emissions are primarily associated with industrial and residential activity, and with oil and gas exploration activities, road and pad construction and use, and abandonment and reclamation. In addition to these criteria pollutants, certain hazardous air pollutants and greenhouse gases may also be emitted.

Air quality impacts may also result if a well blowout or an oil spill occurs, especially if spilled oil is burned to mitigate the impacts of the spill. To reduce air pollutants during oil and gas well exploration, development, and production, potential mitigation measures could include, but not be limited to, Tier II or better drilling engines, low bleed or no bleed pneumatic pump valves, dehydrator VOC emission controls, and tank VOC emission controls.

The BLM analyzes cumulative impacts of criteria air pollutants with respect to the National Ambient Air Quality Standards (NAAQS; see Table 3-2 in Volume 1). Primary standards are designed to protect public health. The primary standards are set to protect the most vulnerable human beings and are legally enforceable. Secondary standards are designed to protect human welfare, such as ecosystem health.

Consistent with 40 CFR Part 69, beginning on December 1, 2010, the diesel fuel designated for use in rural Alaska for all on-road and non-road vehicles and equipment, locomotive, and marine will be ultra-low sulfur diesel fuel (15 parts per million sulfur). Ultra-low sulfur diesel became designated for use for on-road vehicles in urban Alaska on October 15, 2006, for non-road vehicles and equipment on December 1, 2010, and will be designated for locomotive and marine vehicles on December 1, 2012. Urban Alaska refers to those geographical areas of Alaska designated by the State of Alaska as being accessible by the

Federal Aid Highway System. Areas not accessible by the Federal Aid Highway System are rural (Elson 2011).

As a trace constituent in diesel fuel, sulfur compounds may cause adverse air quality impacts through formation of sulfate particulate matter (affecting visibility) and deposition of acidic aerosols. These impacts would be reduced significantly by utilizing ultra-low sulfur diesel fuels. In addition, ultra-low sulfur diesel fuels burn cleaner and produce less light-absorbing carbon particulate matter (soot, also called black carbon). When burned, ultra-low sulfur diesel emissions are much lower than those generated by previous fuels, reducing fine particulate matter (soot), sulfuric acid, and sulfate (visibility) impacts. These impacts may be regionally additive (e.g., increased concentrations from multiple facilities) or synergistic (e.g., photochemical reactions that form ozone).

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Ambient air quality on the North Slope of Alaska is generally good (see section 3.2.2.4, Volume 1) as a result of few pollution sources and good dispersion created by frequent winds, and neutral to unstable conditions in the lower atmosphere, even though oil and gas exploration, development, and production have existed for more than 30 years. Historical emission sources consist mainly of diesel-fired generators in small villages, residential heating, snow machines, all-terrain vehicles, occasional small aircraft, limited local vehicle traffic, and occasional open burning (USDOI BLM 2008).

Oil and Gas Exploration and Development Activities

Oil and gas related emissions originate in field production and drilling areas, such as gas-fired turbines and heaters, incinerators and flaring, diesel-fired power generators storage tanks, fugitive hydrocarbon emissions, and mobile sources (e.g., vehicular traffic and aircraft). Regional sources of emissions consist of oil and gas production facilities including Kuparuk, Milne Point, Prudhoe Bay, North Star, Endicott, and Alpine fields. Trace amounts of air pollutants, including metals, have been detected in vegetation at very low levels. Given its high latitude, the NPR-A is also subject to occasional “Arctic haze” resulting from elevated concentrations of fine particulate matter, primarily from emission sources in northern Europe and Asia (USDOI BLM 2008).

Summary of Past and Present Effects and Their Accumulation

Emissions from sources have contributed to increases in criteria pollutants, hazardous air pollutants, hydrocarbons, and greenhouse gases. It may be difficult to discern whether global climate change is already affecting resources within and adjacent to the planning area. Projected changes are likely to occur over several decades to a century. Therefore, many of the projected changes associated with climate change that could affect air quality, visibility, and atmospheric deposition may not be measurable within the reasonably foreseeable future. Existing climate prediction models are global or continental in scale. There are no tools available to estimate potential impacts of a single greenhouse gas emission source on global climate change (USDOI BLM 2008).

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Emissions on the North Slope as a whole may decrease as the result of technological advances, which decrease air emissions; therefore, air quality impacts from local existing industrial sources may be reduced.

Oil and Gas Exploration and Development Activities

The types and relative amounts of air pollutants generated by oil and gas operations vary according to the phase of activity. During the exploration phase, emissions are produced by (1) diesel-fired equipment required for drilling exploratory and delineation wells, (2) vehicles used in support of drilling activities, and (3) intermittent operations such as mud degassing and well testing. Air pollutant emissions from combustion processes consist primarily of nitrous oxides, with lesser amounts of carbon monoxide, particulate matter, and sulfur dioxide.

During the development phase, the primary emission sources are (1) internal combustion engines or turbines used to provide power for drilling, (2) heavy construction equipment used to install modules and pipelines, and (3) various vehicles and aircraft. The principal development, with lesser amounts of carbon monoxide, particulate matter, and sulfur dioxide.

During the production phase, the primary source of emissions is power generation for heating, oil pumping, and water injection. The emissions consist primarily of nitrogen oxides, with smaller amounts of carbon monoxide and particulate matter. Another source of air pollutant emissions is evaporative losses of hydrocarbons from oil/water separators, pump and compressor seals, valves, and storage tanks. Venting and flaring also contribute to hydrocarbon and sulfur dioxide emissions (USDOI BLM 2008).

In addition to these criteria pollutants, certain hazardous air pollutants may also be emitted. Benzene, toluene, ethylbenzene, and xylenes are common hazardous air pollutants associated with volatilization of oil and gas resources, as is formaldehyde from compressor engines. Depending on conditions, hydrogen sulfide may also be found in oil.

Abandonment and rehabilitation activities would have impacts similar to those of construction since similar equipment and vehicles would be used. Because abandonment would occur at single locations for a short length of time, air quality impacts would be short term. Impacts could be less than those associated with construction if gravel fill was left in place, due to less use of vehicles and machinery. Particulate matter emissions would also be reduced at sites that are revegetated. Greater reliance on technologies and mitigation measures that reduce the need for permanent roads and pads, and reduce the size of the facility footprint, would specifically reduce particulate matter emissions.

The impacts of offshore oil and gas development in the Chukchi and Beaufort seas and construction of roads to support the development would result in increased emissions of criteria pollutants, hazardous air pollutants, hydrocarbons, and greenhouse gases. The extent of the impacts would depend on the size of operation, duration of activities, distance offshore, and mitigation measures imposed by the regulatory agency. Potential oil and gas development to the east (upwind) of the NPR-A would likely result in increases in air pollution depending upon the magnitude of the production operation and distance from the NPR-A. Should the State of Alaska construct a road to Umiat the quantity of particulates and gaseous air pollutants in the NPR-A and in the vicinity of Umiat would increase. The magnitude of the impact would depend upon the amount of traffic, time of day, season, and meteorological conditions.

Potential impacts from future oil and gas activities would be scattered over a large regional area. Emissions associated with routine program activities would increase, although all applicable standards would continue to be met. Maximum concentrations of air pollutants will occur close to facility boundaries, and dissipate rapidly as distance from the facility increases. Thus, it is unlikely cumulative interaction between developments would occur. However, until air pollution emissions in Asia and Europe decline, Arctic haze is likely to persist or get worse. In addition, worldwide emissions of carbon dioxide and other greenhouse gases are anticipated to persist and accumulate in the atmosphere (USDOI BLM 2008).

Contribution of the NPR-A IAP/EIS Alternatives to the Cumulative Effects

Of the five alternatives, Alternative B-1 (lowest amount of leased oil and gas leases offered) would emit the least amount of air pollutants, while Alternative D (maximum oil and gas leasing alternative) would emit the highest amount of air pollutants. Alternative B-2 (the preferred alternative) would result in the second lowest amount of air pollutant emissions followed by Alternative A (no action) and Alternative C.

Conclusion

For the North Slope area as a whole, air quality should improve in those areas where oil production currently is the greatest and will soon decrease, and would decline somewhat in areas where future development is expected to occur. It is likely that new development would be distributed throughout the planning area, keeping regional impacts small, except for localized concentrations in the immediate vicinity of production facilities. Impacts could extend beyond the planning area to offshore development on the Chukchi Sea and Beaufort Sea and areas to be developed east of NPR-A. The extent of the impacts would depend on the size of operation, duration of activities, distance offshore or from a village, and mitigation measures imposed by the regulatory agency.

The cumulative effects of all activities affecting the North Slope of Alaska in the past have caused some deterioration in air quality, well within legal limits (see section 3.2.2.4, Volume 1). Improvements in air pollution control technology would help to reduce emissions from historic levels, as would emission reductions due to overall declining production on the North Slope. Regional air pollutant emissions generated would remain near current levels; approximately 30 percent less than emission levels in the late 1980s. Each proposed individual facility will be required to disclose its potential air quality impacts thorough site-specific NEPA analyses, and demonstrate its continued compliance with applicable local, state, and federal air quality requirements. As facilities are shut down, they would no longer contribute to North Slope air emissions. Particulate matter emissions would also be reduced at sites that are reclaimed.

The U.S. Environmental Protection Agency (EPA) publishes an annual report on anthropogenic greenhouse gas emissions to fulfill commitments of the United Nations

Framework Convention on Climate Change (UNFCCC). The goal of the UNFCCC is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC 2012). The annual EPA report lists emission sources and sinks for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other trace gases. Since the pre-industrial era (1750) to 2010, atmospheric concentrations of CO_2, CH_4, and N_2O have increased globally by 39, 158, and 19 percent (EPA 2012). On October 30, 2009 the U.S. EPA passed a rule for mandatory reporting of greenhouse gases from large sources in the U.S. – 40 CFR Part 98, known as the Greenhouse Gas Reporting Program.

On September 14, 2007, Alaska's Governor signed Administrative Order 238, establishing the Alaska Climate Change Sub-Cabinet and assigning it the responsibility of preparing Alaska's Climate Change Strategy. The Sub-Cabinet formed four advisory groups to handle the various aspects of this task: the Adaptation Advisory Group (AAG), Mitigation Advisory Group (MAG), Immediate Action Work Group (IAWG), and Research Needs Work Group (RNWG). The complete Alaska Climate Change Strategy describes current and foreseeable effects of climate change in Alaska and recommends strategies for responding to these effects (AAG, MAG, IAWG, RNWG, 2009).

The Center for Climate Strategies (CCS) prepared Alaska's greenhouse gas emissions inventory. For consistency and comparison purposes, greenhouse gas emissions are often reported in terms of carbon dioxide equivalent (CO_2 Eq). Human activities in Alaska resulted in about 50.6 teragrams (Tg) of gross CO_2 Eq emissions in 2005. One teragram equals 1x1012 grams (or 1,000,000,000,000 grams). This value is approximately 0.7 percent of total U.S. greenhouse gas emissions (CCS 2009). From 1990 to 2005, Alaska's gross greenhouse gas emissions increased by 30 percent, while national greenhouse gas emissions increased by 16 percent over this same time period. The industrial sector is the largest source of Alaska's greenhouse gas emissions, accounting for 49 percent of total greenhouse gas emissions in 2005. The industrial sector includes fossil fuel combustion at industrial sites and fossil fuel industry emissions associated with oil and natural gas production, processing, transmission and distribution, flaring, fugitive emissions from leaks and venting, oil refining, and coal mining emissions.

Some human activities serve as sinks for atmospheric greenhouse gases. It is estimated that 1.4 Tg of CO_2 are sequestered in Alaska's managed forests. This leads to net manmade emissions of 49.2 Tg CO_2 Eq in 2005. On a per capita basis, Alaskans emitted roughly 79 metric tons (Mt) of CO_2 Eq in 2005, compared to the national average of 24 Mt CO_2 Eq. A metric ton equals 1,000 kilograms (kg) which amounts to 2,204.6 pounds. Alaska's climate and industrial / fossil fuel sectors drive the higher per capita emissions estimates. Gross greenhouse gas emissions in Alaska are expected to continue to grow, reaching 62.7 Tg CO_2 Eq by 2025. The industrial / fossil fuel and transportation sectors are expected to remain the largest contributors to future greenhouse gas emissions growth. Table 4-43 provides a summary of estimated greenhouse gas emissions for Alaska by source category (CCS 2009).

Table 4-43. Alaska historical and projected greenhouse gas emissions by source category 1990 – 2025 (Tg CO_2 Eq)

Source Category	1990	2000	2005	2010	2020	2025
Industrial fuel use/fossil fuel industry	20.5	22.9	24.7	26.5	30.8	31.6
Transportation	11.5	14.9	17.8	18.5	20.1	21.1
Residential/commercial fuel use	3.77	4.33	3.88	3.91	4.12	4.07
Electricity use	2.76	3.19	3.20	3.58	3.47	4.02
Waste management	0.32	0.53	0.63	0.52	0.73	0.86
Agriculture	0.053	0.054	0.053	0.056	0.066	0.073
Industrial processes	0.051	0.20	0.33	0.45	0.75	0.96
Gross emissions	**39.0**	**46.1**	**50.6**	**53.5**	**60.2**	**62.7**
Emissions sinks (forest management)	-0.3	-1.4	-1.4	-1.4	-1.4	-1.4
Net emissions	**38.7**	**44.7**	**49.2**	**52.1**	**58.8**	**61.3**
Percent increase relative to 1990		**15%**	**27%**	**35%**	**52%**	**58%**

(Source: Center for Climatic Strategies (2009)

As described previously, the estimated greenhouse gas emissions for the proposed action and for all the alternatives represent a minuscule fraction of the net greenhouse gas emissions for the State of Alaska. Although the cumulative effects of global greenhouse gas emissions are well-understood, our current scientific understanding of climate change does not allow us to relate specific sources of greenhouse gas emissions to any specific climate-related regional or global impacts. Further, since the specific effects of the proposed action, which may or may not contribute to climate change, cannot be determined, it is not possible to determine whether any particular action will lead to significant climate-related environmental effects.

Potential impacts to air quality due to climate change are likely to be varied. For example, if global climate change results in a warmer and drier climate, increased particulate matter impacts would occur due to increased windblown dust from drier and less stable soils. Alternatively, reclamation efforts may be more successful with more favorable conditions for plant growth. Warmer temperatures are also likely to reduce emissions from combustion sources used for residential heating, and may enhance dispersion of air pollutants (USDOI BLM 2008).

4.8.7.2 Paleontological Resources

Paleontological resources (the fossil remains of plants and animals) are nonrenewable and are susceptible to adverse impact by both natural and human initiated processes. While most of Alaska's North Slope is underlain by fossil-bearing sedimentary strata, most of the remains are of the marine plant and invertebrate (animals without a backbone) variety and are so numerous that the potential impacts addressed here do not present a measurable threat. Vertebrate fossils (animals with a backbone) are much less common and any impact to them is generally considered to be consequential. Most vulnerable of this fossil type are Pleistocene-age remains, which are most often present in surface/near-surface deposits, the contexts most susceptible to impacts from oil and gas exploration and development activities.

The vertebrate paleontological record in the NPR-A spans a period of at least 350 million years. Over that period of time there have been hundreds of significant alterations to the geology, geomorphology, climate, and landscape of the region. The landscape as it exists today is less than 8,000 years old and provides few if any clues to what the region was like in the distant past. Therefore, it provides few hints as to the likelihood of where paleontological remains may lie. For that reason it is assumed that paleontological materials could be encountered anywhere within the NPR-A.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities, including field camps associated with data gathering programs, scientific studies, recreational use, overland transportation/freight hauling, utility terrain vehicles and snowmachines, have the potential to impact surface/near-surface paleontological resources. Paleontological research and excavation, necessary for the recovery of scientific data, have contributed directly to the displacement of paleontological resources as has unauthorized collection of paleontological material resulting from recreational activities. In the early days of freight hauling between villages, construction of Distant Early Warning-Line and other military sites, and village-related development on the North Slope, impacts to the surface/near-surface of the landscape occurred regularly. Those impacts were primarily the result of few if any regulations governing such activities, and the low level of awareness/concern as to the potential adverse effects. However, given the scope and extent (an estimated 7,100 acres) of these activities, with the exception of unauthorized collection, limited direct impact to paleontological resources seems to have occurred.

Oil and Gas Exploration and Development Activities

Ground-disturbing activities associated with oil and gas exploration and development have impacted paleontological resources. During early seismic work the methods and equipment used to transport camps across the landscape caused more surface disturbance than those used today. The technology of the day required long, intersecting seismic lines with data acquisition accomplished primarily by drilling boreholes, loading them with dynamite and detonating the dynamite to produce the force waves needed for data collection. Prior to the mid-1970s, operations on the North Slope were less aware and were subject to fewer regulations regarding impacts to the landscape than today.

The excavation of gravel to construct roads, pads, and other facilities on the North Slope since the mid-1960s has resulted in impacts to paleontological resources. Most mammalian fossils are of Pleistocene age, which also is the age and origin of most North Slope gravel sources. Therefore, the more gravel deposits that are excavated for development infrastructure, the greater possibility that impacts to paleontological resources will occur. By rough estimate, to date, around 7,000 surface acres have been disturbed for gravel mines on the North Slope leading to the extraction of an estimated 495 million cubic yards of gravel.

During the past several decades, greater reliance on technologies that reduce the need for gravel to construct permanent roads and pads and reductions in the size of the facility footprint, as well as a slowing of oil development activities, have substantially reduced the amount of area disturbed annually to extract gravel resources. In addition, regulations that require surveys for and prohibit unauthorized collection of paleontological materials have also slowed the cumulative impact to paleontological resources.

Summary of Past and Present Impacts and Their Accumulation

Paleontological research and excavation, non-oil and gas development, recreation, and oil and gas exploration and development have resulted in impact to paleontological resources on the North Slope, either from stratigraphic disturbance, destruction, or unauthorized collection. If paleontological resources removed in the past have been preserved in museums or other institutions, their losses should not be viewed as negatively cumulative. On the North Slope, approximately 2,500 acres have been disturbed or covered with gravel for non-oil and gas development. Approximately 1,750 acres have been disturbed by blading roads, exploration sites, and airstrips. Gravel mining has disturbed about 7,000 acres. Another 9,200 acres have been covered with gravel to create pads and roads (Table 4-38). Paleontological resources in these areas could be damaged, destroyed, or buried under gravel. Most of these impacts have occurred outside the NPR-A. Recent technological developments, including use of snow trails, ice roads and pads, Rolligons, horizontal drilling, and development that does not require a gravel road linkage to the Prudhoe Bay-Kuparuk infrastructure have reduced the amount of surface disturbance associated with exploration and development activities, reducing potential impacts to surface/ near-surface paleontological resources.

A very small amount of paleontological material is discovered as the result of ground disturbing activities associated with human generated activities on the North Slope. Most of the material is revealed because it is exposed as a result of natural erosion. Typically, erosion occurs as a result of the action of flowing water, but also can occur as a result of wind, seasonal freezing and thawing, ground subsidence due to the thawing of permafrost, and solifluction (the downslope the movement of soil as it thaws). Natural erosion, and its impact on paleontological resources, is difficult to assess because in most cases it is regarded as positive by scientists as it facilitates discovery rather than as a negative impact to the resource. Some of the most important paleontological locales on the North Slope, including the world class "Liscomb Bone Bed" in the NPR-A, are associated with the exposure of geologic sections resulting from erosion. A possibly serious future concern is what the effect of global warming will be on the North Slope permafrost regime and the impact on paleontological resources.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Vertebrate paleontological resources are distributed unevenly across the North Slope and deposits are often unknown until some sort of disturbance occurs, making it difficult to assess future potential cumulative impacts to the resource. However, it is anticipated that village-related development will continue across the North Slope apace with that of oil field development. In most cases, this can be viewed as infrastructure expansion, which generally equates to building gravel pads and access roads and trenching for water and sewer lines as well as gas lines for local use. These activities are viewed as the most likely to impact paleontological resources.

Recreational activity is expected to increase primarily in the form of guided float trips and big game hunting mostly within the Colville and Utukok drainages. Other than unauthorized collection, it is anticipated that there will be no measureable impacts to paleontological resources associated with these activities. Future scientific studies, paleontological survey, excavation and collection as well as well as geological and archaeological studies will impact the resource but the impact will be ameliorated because the materials will be used for scientific and educational purposes. Wintertime overland transportation activities will probably increase although in most cases established routes will continue to be used, which, coupled with winter conditions, should greatly reduce potential impacts to surface/near-surface paleontological resources.

Oil and Gas Exploration and Development Activities

The more activities associated with oil and gas development that occur, the larger the area affected and the greater the possibility that vertebrate paleontological resources will be impacted. Other than Pleistocene and some Tertiary age paleontological resources, fossil materials are usually deeply buried and therefore protected from most oil and gas related activities. From the standpoint of vulnerability in most settings, paleontological resources, especially pre-Pleistocene age materials, are well protected by nature. Pleistocene age fossils are located on or near the ground surface and are susceptible to impacts. In most cases, surface or near-surface paleontological resources are less likely to be impacted as the result of exploration activities than by development. Nonetheless, most exploration-related operations occur in the low-light conditions of winter and although snow cover offers some protection, it can also obscure surface manifestations, making them difficult to recognize and avoid.

Increased oil and gas development activities on the North Slope would result in an increased need for gravel for infrastructure construction. The excavation of up to 150 million cubic yards of gravel (about 2,200 acres of surface impact) by the end of this century for well pads, roads, and airstrips will impact paleontological resources. Pleistocene age paleontological materials are often present in gravel deposits, which are not common in the northern portion of the NPR-A. As a result it is anticipated that gravel deposits in the region will be highly valued and fully exploited. As more gravel deposits are excavated, the probability for impacts to paleontological resources increases.

New innovations in technology that reduce the amount of surface disturbance associated with oil and gas activities and a slowing of oil and gas development on the North Slope, would contribute to the future protection of paleontological resources and slow the cumulative impacts. Assessments to identify and protect cultural resources frequently identify paleontological resources and contribute to the minimization of impacts to these resources.

Contribution of NPR-A IAP/EIS Alternatives to Cumulative Effects

The greatest potential for adding to cumulative effects to paleontological resources would occur under Alternative D, as all lands within the NPR-A would be available for leasing, and the amount of development proposed under the alternative is greater than for the other alternatives. The potential for cumulative effects under Alternative C would be about 25 percent less than D while Alternative A, the no-action alternative, would be about 43 percent less than D and Alternatives B-1 and B-2, which emphasize the protection of non-oil and gas resources, would be about 52 percent less than D. Because paleontological resources have the potential to occur almost anywhere on the North Slope and their location of occurrence is statistically unpredictable, it is difficult to develop a scenario of future cumulative impact.

Umbrella coverage and protection for paleontological resources on federal lands is provided by the Paleontological Resources Preservation Act. Required Operating Procedure/Best Management Practice E-13 in this IAP/EIS states that lessees will conduct a paleontological resources survey prior to engaging in any potential ground disturbing activity. If paleontological resources are identified during surveys, BLM guidelines and policy require that all potential effects to the resource be mitigated to the satisfaction of the land manager. Additional protection is provided by Required Operating Procedure/Best Management Practice C-2, which affords protection to stream banks, and minimizes soil compaction and impacts to the surface and near-surface of the landscape. Also contributing to the protection of paleontological resources is Required Operating Procedure/Best Management Practice I-1 which requires that all personnel involved in oil and gas related activities be made aware of environmental concerns, including paleontological resources, that relate to the region/work site. Additional protections that are set out in select biologically sensitive areas also provide protections for paleontological resources in that the flood plains, terraces, and banks of specific rivers, which are known to contain paleontological material are safeguarded by construction setbacks. Contributing to these protections are the inventorying and monitoring that has been conducted in the NPR-A by the BLM, cooperators, and permittees both prior to and since leasing began. Carrying forward these and similar protections into the future should provide markedly positive results in reducing cumulative adverse impacts to paleontological resources within the NPR-A.

Conclusion

From a cumulative perspective, probably more paleontological locales have been disturbed and material removed from the North Slope as the result of scientific studies than has been destroyed or removed through unauthorized collection resulting from oil and gas exploration and development as well as other construction related activities. While the scientific endeavors did remove paleontological material from the landscape the material contributed to scientific study, public education, and display in museums. The material impacted in the other circumstances is destroyed. In terms of the amount of paleontological material that probably resides undisturbed on the North Slope the amount that has been impacted by human caused activities is minimal. While the scientific value and significance of the material that was obtained through scientific work is known, the value and significance of material obtained through unauthorized collection or that was destroyed will never be known. This is the greatest potential cumulative impact to paleontological resources.

Because of the unpredictable location, isolated and erratic occurrence, and varying depth of burial, the occurrence and significance of future impacts to paleontological resources is difficult to assess in terms of cumulative impacts. However, if the protections that are currently in place carry forward, then the cumulative impact to paleontological resources would be expected to be minor within the NPR-A.

It should be mentioned that the future effects of climate change loom in regard to assessing future potential cumulative impacts to paleontological resources. Climate change will cause alterations to the environment, ecosystems, and habitats of the North Slope, and if substantial enough could affect vertebrate paleontological resources (Arctic Climate Impact Assessment 2004). The thawing of permanently frozen ground could result in the erosion of riverbanks and beach bluffs, which could result in impacts to known and undocumented vertebrate paleontological deposits. In addition, the thawing of permanently frozen ground could result in decreased preservation of subsurface materials particularly in areas with sparse vegetation and little or no organic soil. Climate change will also cause the alteration of weather patterns. An increase in the frequency and intensity of spring and fall storms is likely to occur with the potential to adversely affect near-shore paleontological deposits.

In the case of paleontological resources, Alternatives B-1 and B-2 would contribute the least toward cumulative impacts. Alternatives A, C, and D progressively have a greater potential for creating cumulative impacts as all of those Alternatives allow more area to be open for leasing.

4.8.7.3 Soil Resources

Cumulative impacts to soils within the NPR-A would occur from exploration and development activities. The infrastructure associated with non-oil and gas, and oil and gas development and transportation is the most important aspect of the cumulative analysis.

Past Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, overland moves by transport vehicles, and use of off-highway vehicles such as four-wheel vehicles and snow machines, have likely caused soil loss and erosion on less than 100 acres in the Planning Area. In most cases, loss of soil and erosion would be temporary, lasting only a few years. Where Caterpillar or similar tractors have been used, or the vegetation has been bladed, scars in the soil persist to this day. An estimated 250 acres of tractor trail/tundra scars were created before 1973; about 50 acres remain evident today (National Research Council 2003). It is unclear if these scars were related to oil and gas development or other exploration.

Distant Early Warning-Line sites and other military facilities, villages, public roads, airstrips, and other non-oil and gas infrastructure have been developed using gravel pads or on bare ground. Approximately 2,500 acres have been impacted by compaction, covering with gravel or other material (including buildings), excavated or contaminated from various activities This includes about 700 acres for Distant Early Warning-Line sites and related development, and 1,800 acres for villages. The loss of soil and soil productivity are likely to persist into the indefinite future.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Much of the Arctic Coastal Plain has been surveyed since 1940, and soil was disturbed to varying degrees depending upon the soil and vegetation type, vehicle type, operator vigilance, and amount of snow cover. Studies of seismic and camp-move trails created in the 1980s showed that only a small portion of seismic trails were still evident 8 years later, yet 5 percent of camp-move trails still showed moderate to high disturbance. The greatest damage occurred where the vegetative mat was destroyed and the underlying soil was exposed. This resulted from tracked vehicles or sleds on skids cutting into hummocks, or from Caterpillar operators making a tight turn and dropping the blade too deeply into the snow. As noted earlier, about 50 acres of tractor trail/tundra scars persist today from past actions of determined use.

Use of newer technologies, including use of vehicles that apply less pressure to the ground and restricting travel to periods when there is adequate snow and frost cover to protect vegetation, have reduced the level of impacts to vegetation and soil. In 2001, a study conducted the summer following seismic work, found little to no impacts to tundra under seismic lines on 30 percent of the plots studied (Jorgenson et al. 2003). Minor impacts were found on 66 percent and moderate impacts were found on 4 percent of the plots; no plots were highly impacted. Camp move trails in this study had little or no impacts on 18 percent, minor impacts on 54 percent, moderate impacts on 29 percent, and high impacts on none of the plots. Impacts to soil were minor in areas with good tundra cover. This study suggested that improvements in the equipment and procedures used for seismic surveys have reduced the amount of impact to tundra and soil.

Other sources of soil loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Based on "Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope" (National Research Council 2003), the adjusted 2011 estimates include approximately 9,500 acres of gravel pads and 6,400 acres of gravel sources had been impacted. Many of these sites were developed before 1977, thus their effects on the landscape have persisted for decades, and are likely to persist for several more.

Oil and Gas Infrastructure. Peat and gravel roads and pads, and gravel mines have caused the direct loss of soil, and also led to the indirect loss of soil from thermokarst and alteration of natural drainage patterns. Through 2001, over 500 acres of peat roads still showed evidence of disturbance, even though most of these roads were constructed over 30 years ago. Gravel has been used to construct over 9,500 acres of roads and pads, while gravel mines have impacted another 6,400 acres. Other impacted areas cover approximately 2,000 acres (National Research Council 2003, page 44). The total area impacted on the North Slope from this infrastructure adds up to approximately 18,400 (500 + 9,500 + 6,400 + 2,000) acres (see Table 4-38 on page 22). Of this amount, approximately 4,500 acres of gravel mines have been reclaimed, but only 70 acres of pads and roads (National Research Council 2003). Even though the lakes left behind by former gravel mines are considered reclaimed due to their value as aquatic habitat, the loss of soil resources is permanent. Thus, impacts to soil and soil productivity persist on approximately 18,400 acres.

Construction of gravel pads, roads, and airstrips has altered the moisture regime of tundra near the structure by changing natural drainage patterns and areas where snow accumulates. Snowdrifts caused by gravel structures have increased the wintertime soil surface temperature and increased thaw depth in soils near the structures. These impacts have been exacerbated by dust deposition and by the formation of impoundments. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003). In flat, thaw-lake plains on the North Slope, one study published in 1987 found that past gravel construction resulted in upslope water impoundment and thermokarst erosion equivalent to twice the area directly covered by gravel (Walker et. al. 1987). However, cumulative impacts recently reported by the National Research Council found that the ratio of direct to indirect impacts from gravel structures such as roads was about one to one (National Research Council 2003, page 95). If so, the condition of an additional 18,400 acres of soil may have been altered due to hydrologic changes on the North Slope. Based on this information, the total of direct and indirect long term impacts to soils from past and present oil and gas activities on the North Slope covers approximately 36,800 (18,400 direct + 18,400 indirect) acres. The NPR-A comprises only 22.8 million acres of the 61 million acres of the North Slope so the impact is about 0.2 percent of the NPR-A.

Recent technologies, including roadless development, horizontal drilling, and closer spacing of wells on pads, and a slowing of oil field development, have greatly reduced the amount of surface disturbance needed to develop and produce oil. As a result, the annual amount of surface disturbance associated with gravel roads and pads has slowed substantially during the past 2 decades.

Spills. Overall, the effects of spills on soil have not accumulated on the North Slope because all but two of the spills have been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003). The largest spill in the North Slope oilfields (over 200,000 gallons) occurred in March of 2006; it is likely that some soil was damaged during the clean-up and remediation efforts, which are still ongoing.

Summary of Past Effects and Their Accumulation

Based on the above analysis, approximately 2,500 acres of direct impacts to soil from non-oil and gas activities persist today. Oil and gas activities have caused approximately 18,400 acres of direct impacts to soil that persist today; another 18,400 acres of indirect impacts have also occurred, some of which persist today. Therefore, a total of approximately 39,300 (2,500 + 18,400 + 18,400) acres of soil resources on the North Slope still show impacts from all past activities, of which 12,800 acres is attributed to gravel mines. Since most of these impacts are associated with ongoing non-oil and gas residential and commercial development, and oil and gas activities, these impacts to soil are additive to future impacts and would be likely to persist for several decades or more. However, the rate at which soil is disturbed by development has slowed substantially in recent years due to advances in technology and a slowing of oil field development on the North Slope.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

It is anticipated that villages will continue to grow in the future due to population growth and to provide services and infrastructure to support new oil and gas development on the North Slope. The amount of area that would be disturbed by new development is projected to increase by 2 percent annually for the next 40 years or so and then level off (see section 4.8.2). Assuming community infrastructure and footprint grow at roughly the same pace as population, there would be approximately 3,600 acres of community footprint by the time population may level off in the 2040s.

Although not part of the development scenario for the Planning Area, it is reasonably foreseeable that the State of Alaska would build a new highway from the existing oil fields or the Trans-Alaska Pipeline System to the Planning Area. One proposal is to build a road from the Spine Road to Nuiqsut. Assuming a length of 18 miles (to connect the existing Spine Road to a proposed bridge at the Colville River) and assuming the same impacts for construction as for other gravel roads and pads, such a road would cover approximately 80 acres of soil for the road and 20 acres of soil would be lost from development of gravel mines. Another proposal is to build a road from Trans-Alaska Pipeline System to the Planning Area that would be entirely outside the planning area. This road could be 100 or more miles in length, and would directly impact 425 acres or more of soil and indirectly impact substantially more soil. An additional 80 acres of soil would be lost due to development of gravel mines.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Based on past seismic activity on the North Slope, the BLM assumes continuation of the recent experience of three to four seismic crews active there each winter and that the miles of 2-D and 3-D surveys, the associated camp-move miles, and the proportion of 2-D and 3-D surveys anticipated in Northeast NPR-A will over time approximate the average throughout the North Slope. Based on these assumptions, approximately 86,400 acres would be covered annually by seismic activities, including camp moves, on the North Slope. Soil and vegetation recovery studies have shown that most impacts to soil from seismic activities and exploration should be minor and short term (National Research Council2003). However, approximately 125 acres of that yearly total may still show moderate to high levels of disturbance a decade later.

Oil Development and Production. Future development and production could occur on the North Slope in NPR-A, the Chukchi Sea, onshore between the NPR-A and the Arctic National Wildlife Refuge, and in the Beaufort Sea (see section 4.8.3.3). New development, especially for economically marginal fields of oil, would most likely occur near existing fields so that infrastructure systems could be shared. Additional long-term impacts to soil resources would occur as a result of this development.

Oil and gas development and operation would affect soils by compacting and damaging soils under gravel pads, gravel roads, and gravel airstrips; excavating material sites; constructing vertical support members for elevated pipelines; and excavating trenches for buried pipelines. These impacts would be long-term. Construction of gravel pads, roads, and airstrips could also result in indirect effects to soils by altering the moisture regime of tundra near the structure due to changing natural drainage patterns and areas where snow accumulates. Snowdrifts caused by gravel structures would increase the wintertime soil surface temperature and increase thaw depth in the soil near the structures. These impacts would be exacerbated by dust deposition and by the formation of impoundments. These factors could combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures. This can result in approximately one acre of indirect impacts to soil for each acre of direct impact (National Research Council2003, page 95).

Offshore development associated with leases in the Beaufort Sea could impact small areas along the coast for staging and storage of materials, but is unlikely to impact large areas of soil. Similarly, development in the Chukchi Sea could require a pipeline across the NPR-A. However, long-term impacts to soils from elevated pipelines are mainly associated with vertical support members that create only small areas of soil disturbance. For example, in the NPR-A it is estimated that approximately 600 miles of elevated pipeline would create only 16 acres of long-term, direct surface disturbance from vertical support members (Table 4–14 in Volume 2). Additional areas of soil would be impacted if some buried pipelines were required.

Additional development and production could also occur east of the NPR-A between the NPR-A and the Arctic National Wildlife Refuge. This analysis assumes that approximately 88 percent of the estimated undiscovered oil in the area would be brought into production in the foreseeable future (see section 4.8.3). No estimates are currently available for the amount of additional infrastructure needed to produce this oil or gas, if a gas pipeline is constructed to deliver North Slope gas to markets. However, production would likely use a combination of existing infrastructure and new infrastructure resembling the Alpine field. Although the footprint would be relatively small compared with the total area, some additional areas of long-term disturbance to soils would be required for gravel staging areas, gravel roads, gravel pads, and other semi-permanent infrastructure.

Under Alternative D, which opens the entire planning area to oil and gas development in the NPR-A, long-term direct impacts to soil resources could occur on approximately 31,400 acres (excluding material sites) (see Table 4-40 on page 45). In addition, approximately 10,760 acres of gravel footprint can be attributable to gravel source development for a total of approximately 25,001 acres (see section 4.8.3). Assuming a one to one ratio for direct to indirect impacts, a total of approximately 50,002 acres (25,001 + 25,001) of soil could be impacted long term by gravel footprint from future oil and gas development on the North Slope.

Trenching to bury gas pipelines, both one from the North Slope to outside gas markets, and pipelines on the North Slope to bring gas to the beginning of that market pipeline, would alter the soil profile for all the area excavated. Based on estimates of disturbance associated with burying pipeline in the planning area and extrapolating that very roughly to other areas, it is estimated that approximately 3,775 acres of soil would be disturbed by being excavated to bury gas pipelines in the NPR-A. An additional area would be disturbed by equipment and temporary overburden storage in the course of burying the pipelines. a total of 12,582 (Table 4-14 in Volume 2) acres could be impacted by construction of future gas pipelines on the North Slope.

The total future direct and indirect impacts to soil resources from future oil and gas development on the North Slope would be the sum of impacts from the gravel footprint, excavation of material sites, and construction of elevated and buried pipelines described above. Therefore, the total area of long term impacts to soils from future development would be approximately 73,343 (50,001 (gravel footprint material sites + pipelines) acres. These impacts are additive to the impacts to soil on approximately 26,500 acres that have accumulated from past and present oil and gas activities that persist today (see “Summary of Past Effects and Their Accumulation” on page 83). Assuming a one to one ratio for direct to indirect impacts is already included in these figures, a total of approximately 76,501 (50,001 + 26,500) acres or 0.34 percent of soil could be impacted long term by gravel footprint from future oil and gas development in the NPR-A.

Under Alternative B-2 these impacts would be reduced to 7,277 for direct impact of long term impacts of gravel pads and pipelines, 9,797 acres for gravel mining bringing the total direct impact to 17,074 acres and a combined direct and indirect impact of 34,148 acres. When combined with the existing impacts of 26,500 acres the cumulative impact under Alternative B-2 would be 60,648 acres or approximately 0.27 percent of the NPR-A.

Offshore development associated with leases in the Chukchi and Beaufort seas could impact small areas along the coast for staging and storage of materials, but is unlikely to impact large areas of soil.

Oil Spills. Oil spills could impact soils by altering vegetation and from soil disturbance associated with clean-up activities. The oil alone would decrease plant growth, but oil spills probably would leave the surface organic mat intact. Spill cleanup, however, would be more likely to damage soils. Cleanups are not always well controlled; heavy traffic and digging, which are common cleanup methods, result in damaged soils. Oil-spill cleanup would mitigate impacts on soils only if cleanup methods and operations were very carefully controlled and minimized surface disturbance. The area affected would be limited to the area immediately adjacent to and covered by the spill.

The projected increase in activity levels combined with the potential problem of aging pipelines could result in more spills. However, the recent large spill in March 2006 caused by pipeline corrosion may lead to better overall maintenance, oversight, and prevention of potential problems that can lead to spills. Overall, the effects of spills on soil have not accumulated on the North Slope because the spills have generally been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003).

Abandonment. As more oil and gas development and production occur on the North Slope, the more need there will eventually be for abandonment of infrastructure and rehabilitation of soil resources. Removal of aboveground facilities, pipelines, bridges, and power poles would have a minor impact on soils and permafrost. Soils and permafrost would remain unaffected for as long as gravel structures such as pads and roads were maintained. Once maintenance of the roads and pads ceased, thaw subsidence in ice-rich areas could result in settling of the gravel structures into thermokarst troughs. Removal of the roads and pads would accelerate thaw subsidence, but would also accelerate the reclamation process.

The North Slope presents special technical challenges to restoration and recovery. Extremely cold temperatures, meager precipitation (5 to 7 inches per year), and the short growing season lengthen recovery times substantially beyond those possible elsewhere in the United States. Natural recovery of disturbed sites to original soil and plant conditions has been estimated to require 600 to 800 years for upland sites and 100 to 200 years for marsh sites (Alaska Oil and Gas Association 2001).

Contribution of Alternatives to Cumulative Effects

Seismic activities could disturb up to 785,000 acres of soil under the action alternatives. The number of acres disturbed annually would be similar to the amount of acreage that has been disturbed annually by seismic surveys during the past decade in the Planning Area. It is assumed that seismic train moves would originate from Kuparuk, Barrow, or Umiat and traverse the Planning Area in each direction. However, much of this distance would be along an ice road that is built annually from Kuparuk to the Alpine oil field, limiting most impacts of the seismic train outside of the Planning Area to the minor impacts associated with ice roads. Nonetheless, impacts associated with seismic operations occurring in the NPR-A would be additive with impacts from seismic operations in other portions of the North Slope.

If oil prices average $80 per barrel, development in the NPR-A would directly impact 9,902, 7,505, 8,402, 15,311, and 16,329 acres of soil for Alternatives A through D, respectively, and indirectly impact 246,888 to 488,117 acres of soil. Impacts associated with the NPR-A would be additive to past, present, and reasonably foreseeable future soil impacts on the North Slope.

Pipelines and infrastructure that might be developed as a result of Alternatives A, C or D could make it more feasible to develop offshore leases in the Beaufort Sea north of Teshekpuk Lake. In contrast, Alternative B-1 would greatly lessen the potential for offshore development in the Beaufort Sea as it would prohibit infrastructure to come ashore in NPR-A east of Barrow. Alternative B-2 would provide for offshore development to come ashore along most of the NPR-A coast east of Barrow, but by making much of the lands along the Beaufort Coast unavailable for leasing, the alternative reduces the potential for synergistic offshore and onshore development that would be possible under Alternatives A, C, and D. Support for offshore development may require additional pipelines to connect to existing pipelines in the planning area. However, long-term impacts to soils from elevated pipelines are mainly associated with vertical support members that create only small areas of soil disturbance. Additional areas of soil would be impacted if some buried pipelines were required.

Conclusion

Cumulative impacts to soils on the North Slope would occur from activities associated with non-oil and gas development and oil and gas development. Impacts from non-oil and gas development are relatively small compared to those from oil and gas development and have impacted approximately 2,500 acres (1,800 acres for villages + 700 acres for Distant Early Warning sites). The amount of area that would be disturbed by expansion of villages is projected to increase by 2 percent annually for the next 40 years or so and then level off (see section 4.8.2). Assuming community infrastructure and footprint grow at roughly the same pace as population, there would be approximately 3,600 acres of community footprint by the time population is expected to level off in the 2040s. In addition, approximately 700 acres of soil impacted by Distant Early Warning-Line sites are expected to persist. Therefore the total long-term cumulative impact to soil resources on the North Slope from non-oil and gas activities (past, present, and foreseeable future) would be approximately 4,300 acres (3,600 acres for villages + 700 acres for Distant Early Warning-Line sites).

The total of direct and indirect long-term impacts to soils from past and present oil and gas activities on the North Slope covers approximately 35,000 acres. Impacts to soil resources from future oil and gas development include exploration activities and construction of gravel pads, gravel roads, gravel airstrips, gravel staging areas, excavation of material sites, oil pipelines, and possible gas pipelines (both to market outside the North Slope and within the North Slope). The duration of the impacts would range from short term (less than 1 to 5 years) if the soil was lightly disturbed (i.e. most seismic activity, ice roads, and ice pads) up to several decades or longer if the soil was covered by gravel, removed, or permafrost was thawed creating thermokarst. Impacts associated with exploration and development activities in the planning area would be additive with impacts from activities in the NPR- A and across the North Slope.

Under Alternatives A, C, and D, the northeastern part of NPR-A is more likely to be developed than under the other alternatives. Infrastructure such as pipelines and central processing facilities developed in this portion of the planning area would make marginal discoveries in the NPR-A, and offshore areas to the north of Teshekpuk Lake, more likely to be developed in the foreseeable future. This would create a greater area of soil disturbance than under Alternatives B-1 or B-2. Overall, the area of soils impacted long term by past, present, and foreseeable future oil and gas development would be approximately 113,761 acres (26,500 + 10,760 past and present + 76,501 future acres). The North Slope region is approximately 57 million acres. Therefore, compared to the area of the North Slope, this would be a relatively small area of soils impacted (about 0.2 percent), even with the entire planning area open for development (Alternative D).

If global climate change persists, the cumulative effects to soil from oil and gas development, and non-oil and gas development, on the North Slope could be greater than predicted. If the climate warms, the permafrost will thaw to an increased depth each season, which will cause varying degrees of impacts on subsidence, soil moisture, and vegetation. Since there is great depth of the permafrost on the North Slope it would take several decades of warming at the predicted rate before it would transition into discontinuous permafrost (National Research Council 2003, page 59). However, if the permafrost continues to warm, its ability to support structures would diminish, which could affect development on the North Slope. Thicker gravel may be needed to support structures, and abandoned work pads and roads could become unusable as they are cut up by deep polygonal troughs over thawing ice wedges, or by other thermokarst degradation.

Coastal regions with underlying permafrost are especially vulnerable to erosion as ice beneath the seabed and shoreline thaws from contact with warmer air and water. The projected increase in air and water temperature, reduction in sea ice, and increase in height and frequency of storm surges are expected to have a destabilizing effect on coastal permafrost, resulting in increased erosion. Since oil and gas activities can also cause local thawing of permafrost, the effects of a warming climate would add to the thawing effects of direct and indirect impacts from oil and gas development activities along coastal boundaries. These cumulative effects could occur locally in areas of surface disturbance near coastal boundaries.

Numerous technological advancements have been made during the decades of operations on the North Slope that have allowed current development activities to proceed with less environmental impact to soil resources than previous operations (National Research Council 2003). However, some short-term disturbance and permanent long-term impacts to soils are inevitable. New innovations in technology that reduce the amount of surface disturbance associated with oil and gas activities, enforcement of regulations that require the assessment and protection of soil resources before ground-disturbing activities can occur, and a slowing of oil and gas development on the North Slope, would contribute to the future protection of soil resources and slow their cumulative loss. Some soil would be restored as sites are abandoned and reclaimed. However, due to the harsh Arctic climate, it could take several hundred years for soil productivity to reach pre-disturbance levels on abandoned pads and roads.

4.8.7.4 Water Resources and Water Quality

Minor cumulative effects to water resources and water quality will occur from non-oil and gas activities in the NPR-A. Cumulative effects to water resources and water quality from oil and gas exploration, development, and production in the NPR-A and across the North Slope would result from: (1) thermokarst from damaged vegetation and streambanks; (2) disruption of natural flows by roads, pads, and river crossing structures; (3) water withdrawals from lakes; (4) gravel mining; and (5) spills.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Activities not related to oil and gas exploration have the potential to impact water resources and water quality. Non-oil and gas activities, including scientific excavations, temporary tent camps, overland moves by transport vehicles, aircraft landings and use of gravel strips, boats, use of off-highway vehicles such as four-wheel vehicles, snowmachines, hazardous material or debris removal, legacy well plugging, and small fuel spills, all have the potential to impact water resources and quality. These impacts are usually localized and result in short-term impacts for up to a few years.

Former Distant Early Warning-Line Stations, active and inactive Air Force radar sites and other military facilities, villages, public roads, airstrips, and other non-oil and gas infrastructure have been developed using gravel pads or on bare ground. Approximately 2,500 acres have been impacted to date. Non-point runoff from these disturbed sites continue to contribute to impacts on water quality and alter natural drainage patterns.

Oil and Gas Exploration and Development Activities

Past and present activities on the North Slope that have affected the water resources and water quality include seismic exploration and overland transport, gravel road and pad construction, gravel mining, ice road and ice pad construction, and water withdrawals to support the construction, drilling, and operations phases and construction of ice roads and pads. Impacts on hydrology and water resources include changes in drainage patterns, impoundments, increased turbidity from dust along roads, creation of erosion and sedimentation conditions at stream crossings, lowered lake levels, and spills.

Seismic Activities and Exploration. Much of the NPR-A has been surveyed since 1940, and seismic activities have disturbed the vegetation over much of the NPR-A. The greatest damage occurred where the vegetative mat was destroyed and the underlying soil was exposed. This disturbance has resulted in thermokarst erosion and localized impacts to water quality.

Other potential water quality impacts are associated with older exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Most of these sites were developed before 1977, thus their effects on the landscape, including soil erosion and sedimentation into nearby water bodies, have persisted for decades, and are likely to persist for several more. Over 500 acres of peat roads still showed evidence of thermokarst, even though most of these roads were constructed over 30 years ago.

Offshore seismic survey activities have occurred for many years in the Chukchi and Beaufort Sea Planning Areas and are expected to continue in the future during the open water season (July through November). Exploration seismic surveys include the use of seismic source vessels, towed sound source arrays and receiver cable arrays, and support vessels for marine mammal monitoring and crew/supply transport. In-ice surveys using icebreakers have been proposed for October through December but none have yet been conducted in U.S. waters. A typical seismic survey is conducted in less than 60 days. Localized impacts to offshore water quality are possible and could occur from small fuel-transfer spills, permitted discharges, and changes to the surface flow regime of the area.

Water Withdrawals and Use. Ice roads and pads, drilling operations and camps and facilities require substantial amounts of fresh water from nearby lakes. The volume of water withdrawn from each lake or reservoir would be stipulated in a Temporary Water Use Permit issued by the State of Alaska and would depend on the depth of the lake, the amount of water available below the ice and use of the water body by fish. Surface water withdrawal permitted under the State does not diminish the authority of BLM to accept or alter water withdrawal conditions. The impact of water withdrawal from tundra lakes depends on the capacity of the water bodies to recharge annually from snowmelt. Withdrawals from the same lakes near processing facilities could lead to long-term lowered lake levels, which would require additional monitoring and alternative water sources.

If lakes do not fully recharge annually from snow meltwater, lakes could become shallower, freeze to the bottom, and no longer provide adequate habitat for fish. Lake recharges could be required to be monitored at permitted water sources as a condition of the water use permit. If lake levels do not recharge by the following spring snow melt, future freshwater withdrawal quantities would be limited to ensure complete annual recharge. Previous studies have shown only minor short-term impacts from water withdrawals and lakes were fully recharged by the end of the following summer after winter water removals (Baker 2002; Hinzman et al. 2006). Recording natural lake levels before water withdrawal and monitoring lake levels after spring recharge allows water withdrawal volumes to be adjusted to ensure lake level maintenance.

Drainage Patterns. Natural drainage patterns have been altered by the construction of roads or pads in or across wetlands or drainage areas. During spring ice break-up, there is substantial flow across expansive wetlands into lakes and streams. When long stretches of gravel roads or pads interrupt flow, the difference in water surface elevation from one side of the pad or road to the other can create temporary or permanent impoundments that produce high-velocity water flow in the cross-pad or road drainage structures (usually culverts), resulting in localized streambank and thermokarst erosion, channel scour, and downstream deposition of sediment.

Channel crossing structures are typically narrower than streams during breakup and result in higher stage elevations and lower velocities upstream of the crossing and lower stage and higher velocities downstream of the crossing, resulting in sediment deposition upstream and erosion downstream. Improper sizing of culverts or placement of gravel fill has resulted in erosion from pads or roadbeds adjacent to streams or lakes. Long-term effects would be changes in channel morphology and in the composition of lake and stream bottom materials.

If culverts are not properly installed or sized, water flows can be affected, ice jams form, or temporary or permanent impoundments created. Impacts to water resources and quality from impoundments, scour, sedimentation, and thermokarst erosion, associated with bridges, culverts, and pipes would persist and accumulate over time.

Gravel Structures. Through 2011, over 9,500 acres of gravel pads and roads were constructed in association with oil-field development on the North Slope. Gravel roads and pads have caused thermokarst and alteration of natural drainage patterns. Construction of gravel pads, roads, and airstrips has altered the moisture regime of tundra near the structure by changing natural drainage patterns and areas where snow accumulates. Snowdrifts caused by gravel structures have increased the wintertime soil surface temperature and increased thaw depth in soils near the structures. These impacts have been exacerbated by dust deposition along roads, which increases turbidity of adjacent water bodies and by the formation of impoundments. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003).

Gravel Mine Sites. Improper siting of gravel mine sites has resulted in changes to the configuration of stream channels or lakes, stream-flow hydraulics or lake dynamics, erosion and sedimentation. Estuarine intrusion into flooded gravel mines from adjacent river bodies can influence water quality, resulting in stratification of water with distinctly different characteristics. Gravel removal for permanent gravel roads and drill pads has resulted in over 6,400 acres of surface impacts, with 5,080 of these acres associated with rivers. However, over 4,550 of these river-associated acres have been rehabilitated by conversion into functional habitat for plants and animals, which has reduced cumulative effects to water resources on the North Slope and, at some sites, provided fish habitat.

Spills and Other Contaminants. Overall, the effects of spills have not accumulated on the North Slope because all but two of the spills have been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003) and ecosystems have generally recovered (Jorgenson 1997). The largest spill in the

North Slope oilfields (over 200,000 gallons) occurred in March of 2006. This 2-acre site met cleanup criteria by May 2006 after backfilling and covering of veggie-mat was completed. There were essentially no impacts to water quality due to the timing of the spill, which allowed cleanup to take place before the spring melt. Long-term monitoring will gauge the success of the restoration efforts. No notable spills into the marine environment have occurred.

Drilling Waste Disposal. In recent years, drilling wastes, which previously were stored in environmentally undesirable surface pits, have been injected into subsurface aquifers for permanent disposal. Although much of the water in aquifers below the impermeable permafrost is too saline to meet standards for legally protected drinking water, some water attains the standard. While water appears plentiful on the surface, the North Slope has an arid climate, and if a significant supply of fresh water exists in deep aquifers, it could be a valuable resource. There is little known about the effect of drilling waste disposal on subsurface aquifers and its cumulative effect (National Research Council 2003).

Marine Waters. Offshore activity in the Beaufort Sea has been limited. Activities that affect the quality of marine waters and flow patterns have included construction of gravel islands and causeways and discharges of materials. Only a few small spills have occurred in marine waters to date, but mechanical recovery, the method allowed by current regulations, is not efficient and only removes a small fraction of the spilled oil, especially in broken ice. Concerns about contamination of marine waters center primarily on the potential effects on marine organisms (National Research Council 2003).

There have been three permitted types of discharges to the Beaufort Sea over the life of the oil fields. First, individual facilities have discharges permitted under EPA's NPDES (National Pollution Discharge Elimination System) program. Second, small or localized discharges have been permitted under the North Slope General NPDES Permit. Third, exploratory drilling discharges were permitted under the Arctic General (or Beaufort General) NPDES Permit under either coastal effluent guidelines or offshore effluent guidelines (Wilson 2001).

Permitted NPDES discharges include effluents from seawater-treatment plants, desalination plants, sanitary-waste-processing units, deck drainage sumps (from offshore production facilities, such as Northstar), temporary construction dewatering, and occasional tests of fire suppression with water. These discharges are permitted for a specific facility, and there are monitoring and reporting requirements. The largest discharges under this program are ocean water and peat detritus (Wilson 2001).

Exploratory drilling discharges are covered under the EPA Beaufort Sea General Permit and include disposal of drill cuttings and fluids from well-drilling operations. Although muds and cutting cannot be discharged onshore, offshore guidelines still allow discharges of muds and cuttings. Monitoring is frequently required as a condition of discharge permits to ensure that discharges do not exceed water quality standards, are not toxic to marine organisms, do not degrade water quality, and do not pose a threat to human health. It is unknown if impacts from discharges to marine water have accumulated.

Past Cleanup Efforts. Past cleanup programs at Point Lonely, Barrow, Distant Early Warning Line sites, and old Navy and test well sites have removed drums, debris, and contaminated soil, which have reduced the likelihood of hazardous materials and reserve pit materials from further impacting local water bodies.

Summary of Past and Present Effects and Their Accumulation

Based on the above analysis, approximately 2,500 acres of direct surface disturbance from non-oil and gas activities have impacted waterbodies and drainage patterns. Through 2011, oil and gas activities have caused approximately 18,400 acres of direct impacts to lands on the North Slope, and indirect impacts to water resources may have occurred on another 18,400 acres. Since most of these impacts are associated with ongoing non-oil and gas residential and commercial development, and oil and gas activities, these impacts to water resources would be likely to persist for several decades or more. Water withdrawals are required for all oil field operations. Permit regulations have maintained water quality and quantity in lakes as natural recharge processes have been sufficient to recharge the lakes each year.

Through 2011, over 9,500 acres of gravel pads and roads were constructed in association with oil-field development on the North Slope. Inadequate design and placement of structures, culverts, or bridges have caused impoundments, streambank erosion, scour, and sedimentation at stream crossings. This has altered natural sediment transport and deposition, creating scour holes or channel bars. Several spills have occurred on the North Slope, but their effects have been minor and have likely not accumulated. Effects of discharges from offshore facilities and subsurface injection of drilling wastes are largely unknown, but likely have had little cumulative effect on water quality on the North Slope. Large amounts of debris was left on the North Slope from exploration and military activities from 1940 to 1970 that impacted water quality, but clean-up efforts since the 1970s have removed some of the remaining debris.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities will continue to have minor impacts on water resources and water quality. Activities include scientific excavations, temporary tent camps, overland moves by transport vehicles, aircraft landings and use of gravel strips, boats, off-highway vehicles such as four-wheel vehicles, and snowmachines, hazardous material or debris removal, and spills, all have the potential to impact water resources and quality. These impacts are usually localized and, depending on the type and repetitiveness of the activity, result in short-term impacts for up to a few years. Distant Early Warning-Line sites and other military facilities, villages, airstrips, and other non-oil and gas infrastructure located on the North Slope are likely to persist into the indefinite future, and for villages, could double from current levels, approximately 1,800 acres, to 3,600 acres in the 2040s, causing additional water resource impacts outside the NPR-A.

Oil and Gas Exploration and Development Activities

Future impacts to water resources and water quality will result from thermokarst erosion from seismic and overland travel activities and placement of gravel structures, lowered lake levels, altered drainage patterns gravel pads and roads caused erosion and sedimentation, dust effects created by additional traffic on existing roads, spills, drilling waste disposal, discharges to marine waters, clean-up efforts, and abandonment. Offshore oil and gas operations and the use of tankers to transport oil from the Trans-Alaska Pipeline System to west coast refineries could have a cumulative effect on marine and estuarine water resources.

Seismic Activities and Exploration. It is possible that up to 16 seismic surveys would take place (under Alternative D), impacting a maximum of 786,603 acres in the next 30 years, resulting in long-term disturbance of 2,658 acres which may result in some degree of thermokarst. Seismic surveys adjacent to the NPR-A could also impact watersheds draining into BLM lands. This resulting erosion would result from the cumulative effect of seismic activity on the tundra during winter months. These impacts would accumulate and be additive to past effects to water bodies on the North Slope.

Offshore seismic survey activities have occurred for many years in the Chukchi and Beaufort Seas and are expected to continue in the future during the open water season (July through November). Exploration seismic surveys include the use of seismic source vessels, towed sound source arrays and receiver cable arrays, and support vessels for marine mammal monitoring and crew/supply transport. In-ice surveys using icebreakers have been proposed for October through December but none has yet been conducted in U.S. waters. A typical seismic survey is conducted in less than 60 days. Localized impacts to offshore water quality are possible to occur from small fuel-transfer spills and permitted discharges.

Water Withdrawals and Use. Oil and gas exploration and development would require substantial volumes of water from lakes. Future water withdrawals are difficult to estimate since locations and amount of drilling activity will greatly determine the amount of ice roads built. From 1999-2006 water use for exploration in the NPR-A averaged 75 million gallons of water per year or 26 million gallons per well. If up to 268 wells are drilled over the life of this activity plan, then 6,968 million gallons of water may be withdrawn using these averages. Water withdrawals from lakes have the potential to lower water levels if the removed water is not recharged by snowmelt, rainfall, or inundation by rivers following the removal. Previous studies have shown lakes to have fully recharged following spring breakup after water removals in the winter (Baker 2002; Hinzman 2006).

Because the best oil prospects within the planning area and the North Slope are located in specific zones, lakes along these primary exploration and development zones would be used extensively for water during the winter months until permanent development is planned. There is a possibility that pumped lakes may not fully recharge the following summer, but is unlikely since most have sufficient recharge areas or connections to other streams or lakes. If any lakes are not fully recharged or have water quality changes, future withdrawals from these lakes may be conditional based on requirements stated within the permit. However, extensive use may have a long-term cumulative impact on the planning area, especially if water is withdrawn from a majority of lakes in a concentrated area, which could affect the surface flow regime of the area.

Water removed for ice roads, pads, drilling, and camps is somewhat saline because of the exclusion of ions during the freezing of the upper part of the lake. When this water is used for ice roads and pads it can slightly increase salinity locally as it melts. Local snowmelt quickly mixes with and dilutes this water. Depending on how far water is transported, some portion of the removed water will return to the lake from which it was removed or flow into an adjacent drainage area. Cumulative impacts to changes in water chemistry are not expected since the impacts will be localized and very small.

Drainage Patterns. Although roads would be built during the winter months as ice and snow roads, long-term oil and gas development in the planning area and the North Slope would require permanent gravel roads. Up to 1,106 miles of non-ice roadways are projected for maximum developments within the NPR-A. These will likely be in wetlands where drainages are easily altered by road construction and temporary or permanent impoundments are created which divert, impede, or block flow in stream channels, lakes, or shallow-water tracks. Impounded water can produce high flows through culverts, which is likely to produce streambank erosion, channel scour and downstream deposition of sediment if culverts are improperly placed or sized. Long-term effects in channel morphology and in the composition of lake and stream bottom materials could result. BMP E-5, which limits the length and repeated use of roads, would provide a substantial reduction in impacts to water resources since roads are the single greatest factor.

Gravel Structures. Development activities that could contribute to cumulative effects to water resources and quality on the North Slope include oil and gas development in other areas, federal and State offshore oil development (through the construction of supporting onshore infrastructure), State onshore oil development, oil and gas transportation, road construction, and a pipeline to take North Slope gas to market, as well as gas pipelines, assumed in most cases to be buried, to gather North Slope gas to a conditioning plant near the northern terminus of the market gas pipeline. All of these activities involve construction of infrastructure that would affect water quality through dust, impoundments, changes in natural drainage patterns, snow drifting, and oil, seawater or produced water spills.

Pipelines. Additional construction outside of the planning area necessary to deliver oil and gas to interconnect with existing pipelines include an increased number of ice roads and new pipelines. Offshore development in the Chukchi Sea will create on-shore infrastructure and a pipeline extending across the NPR-A to connect with existing pipelines. Impacts from pipeline construction and the accompanying gravel extraction, with its resultant erosion and sedimentation, would be similar to those described under the action alternatives. Though dependent on the actual level and location of implementation, the increase in the overall effect of construction-related activities in the cumulative case would accumulate, but would have a minor effect on water quality.

Gravel Mines. Over 4,350 acres of gravel mines within the North Slope (including 2,300 acres in the NPR-A) may be developed in the future, in addition to the existing 6,400 acres already developed. Improper siting of gravel-removal pits could result in changes to the configuration of stream channels or lakes, stream-flow hydraulics or lake dynamics, erosion and sedimentation. Those changes would in turn result in long-term changes in stream channel and lakeshore sand and gravel-bar formation. It is possible that diversion of floodwaters, increased erosion and sedimentation, and increased thermokarst adjacent to the material sites could occur. Gravel pits are now typically sited on the tundra, rather than in rivers, to minimize the effects described above. Gravel removal for permanent gravel roads and drill pads, however, would still present a long-term cumulative impact to the planning area and to the North Slope in general.

Spills and Other Contaminants. Overall, the effects of spills on soil have not accumulated on the North Slope because all but two of the spills have been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003). The projected increase in activity levels combined with the potential problem of aging pipelines will result in more spills. Cumulative effects would depend on the location, number, size, and seasonal timing of the spills, and concentrations of hydrocarbons. The quality of freshwater within the planning area should not be affected by any of the developments considered in this cumulative analysis, unless there was a large oil spill within or near a fish-bearing lake. The effects of construction activities should be short term and have the greatest impact in the immediate vicinity of the activity. Removal of water from lakes during the winter months would minimally affect water quality. Alternative D estimates up to 553 spills (less than 500 barrels) might occur if completely developed.

Gas Development. If commercial gas development occurs on the North Slope, additional impacts could occur to water resources. Gas pipelines, both the large-diameter pipeline that would take gas south over the Brooks Range to market and smaller pipelines that would take gas from central processing facilities to a conditioning plant at the northern terminus of the gas pipeline, would most likely be buried. Buried gas pipelines have the potential to cause thermokarst, subsidence, and erosion problems that could persist beyond the construction phase. All work on the pipelines will be constructed during winter, to avoid thermokarst and subsidence.

Abandonment. Removal of facilities, particularly roads, bridges, and culverts, would likely cause increased sedimentation and thermokarst erosion immediately after removal. Leaving pads, airstrips, roads, bridges, and culverts in place, particularly without future maintenance, however, would result in longer-term, higher levels of erosion, sedimentation, and upslope impoundment. Leaving the roads in place, but removing bridges and culverts and breaching the roads where culverts had been placed, would reduce upslope impoundment. Ponds could be formed from melting of ice wedges or other ice underlying the gravel facilities. Recovery of disturbed sites on the North Slope is complicated by the fact that any disturbance of the insulating vegetative mat can melt the underlying permafrost, a process that is extremely difficult to reverse and that can continue long after the initial disturbance ends. Recovery times in the Arctic, as elsewhere, depend in part on the nature and extent of disturbance and the type of habitat affected. Reclamation of oil fields, even over a long period of time, would reduce some of the cumulative effects of impoundments.

Drilling Waste Disposal. Drilling wastes are injected into subsurface aquifers for permanent disposal. Although much of the water in aquifers below the impermeable permafrost is too saline to meet standards for legally protected drinking water, some is not. There is little known about the effect of drilling waste disposal on subsurface aquifers and its cumulative effect (National Research Council 2003).

Marine Waters. There has been minimal offshore development in the Beaufort Sea, and no oil and gas development has yet occurred in the Chukchi Sea, but leases held in both the Beaufort and Chukchi Seas underwent exploratory drilling in 2012. Impacts from discharges to marine water have been minor, are likely to remain that way for future similar development, and are not likely to accumulate. Impacts from a low-probability, very large spill are described in section 4.12.4.4. Similar regulation of Chukchi Sea development, should it occur, is anticipated to provide similar protection.

Cleanup Efforts. Water resources and quality may be impacted through future remediation efforts, which may involve plugging of abandoned wells, excavation of reserve pits and contaminated soil, removal of drums and debris and subsequent rehabilitation of affected soils. Removal of this material lessens the likelihood of hazardous materials further impacting local waterbodies but may result in localized short-term impacts during clean-up operations and for some time afterwards.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Impacts to water resources from gravel roads and pads and gravel mines would be proportional to the number of acres developed. For all alternatives, Chukchi Outer Continental Shelf development on water resources would be additive to existing effects already analyzed such that a pipeline traversing the central portion of the NPR-A may provide the only means to process and transport oil and gas extracted offshore. New pipelines from the Chukchi Outer Continental Shelf and western Beaufort Outer Continental Shelf to existing infrastructure near Prudhoe Bay could make sub-economic oil and gas fields in the central and northern NPR-A viable to produce and result in additional roads and gravel mines with their associated impacts. Development in the western Beaufort Outer Continental Shelf could also synergistically benefit development in the northern NPR-A east of Barrow under most alternatives. Alternative B-1, however, prohibits permanent non-subsistence infrastructure along the entire NPR-A coast east of Barrow and could greatly hinder offshore development along this coastline. Alternative B-2 would make much of the lands in northern NPR-A east of Barrow unavailable for leasing, thus reducing the potential for infrastructure in support of Beaufort Sea development leading to synergistic development in NPR-A, though under Alternative B-2 infrastructure in support of offshore development could traverse most lands east of Barrow.

A total cumulative North Slope gravel footprint of 31,400 acres could be created, which would include 9,500 acres of existing footprint east of NPR-A and 11,450 acres in NPR-A under Alternative D, assuming maximum development and development of projected economically developable undiscovered resources. Impacts from gravel mines would also be proportional to the amount of gravel required, being the greatest for Alternative D. The total cumulative North Slope gravel mine footprint is estimated as 10,760 acres, which includes 6,400 acres of existing footprint east of NPR-A and 2,300 acres in the NPR-A under Alternative D. Other gravel footprint and gravel mine site acreage created from the road to Umiat, commercial gas pipeline and unconventional developments could result from developments within NPR-A. All of these activities involve construction of infrastructure that would affect water quality through dust, impoundments, changes in natural drainage patterns, snow drifting, and oil, seawater or produced water spills. These impacts would be long-term and would accumulate.

Conclusion

Impacts from activities other than those associated with oil and gas development would be minor. It is anticipated that villages will continue to grow in the future due to population growth and to provide services and infrastructure to support new oil and gas development on the North Slope. The amount of area that would be disturbed by new development is projected to increase by at least 2 percent annually for the next few decades. These impacts are additive to the impacts to water bodies that have accumulated in the past and persist today, but in the context of the NPR-A and North Slope, these cumulative impacts would be small. Of this, gravel mining for oil and gas development would account for a total of 10,760 acres by the year 2100. These actions have the potential to add to the cumulative loss and degradation of water resources. Impacts to water resources and water quality would be additive to past, present, and reasonably foreseeable future impacts on the North Slope. The majority of the impacts would result from oil and gas development activities, with construction of roads, permanent drill pads, stream-crossing structures, and water use from lakes during the winter months being the major contributors. Because of the abundance of water resources on the North Slope, the overall cumulative impact to water resources on the North Slope and in the NPR-A would probably be small in magnitude and most impacts would be local in nature. These local impacts could be substantial and long term because of the concentration of promising oil and gas plays in specific areas. There could be synergistic effects on water resources and quality that would take place in the Beaufort and Chukchi Seas. This would occur if a large offshore discovery near the NPR-A would make the development or expansion of an oil field elsewhere in the NPR-A economically feasible, or provide the means to process and transport offshore oil and gas and thus possibly supply a critical prerequisite to offshore development. The implementation of the lease Stipulations D-1, E-2, G-1, K-1 and K-2 and Required Operating Procedures/Best Management Practices A-1 to A-7, B-1, B-2, C-2 to C-4, E-6, E-8, and L-1 required for protection of water resources under each alternative should reduce the cumulative effect to water resources from oil and gas, and non-oil and gas, activities in the planning area to an acceptable level.

4.8.7.5 Vegetation

Vegetation is a renewable resource; impacts to vegetation do not necessarily accumulate and are often reversible. However, due to the harsh climate and short growing seasons on the North Slope, it may take plants decades to centuries to recover from some disturbances. Oil and gas exploration and development are the primary anthropogenic activities in the NPR-A that contribute to cumulative effects on vegetation both within the NPR-A and throughout the North Slope. The greatest impacts occur where vegetation is removed or buried under gravel or other material that destroys the vegetation. These impacts can persist after gravel is removed due to the potential for thermokarst and changes in soil structure. In the long term, global climate change may have a greater and more persistent effect on vegetation on the North Slope than oil and gas activities. Other factors that contribute to the cumulative loss or disturbance of vegetation include permitted activities such as non-oil and gas overland moves and development, scientific data gathering, and recreational use by the public. Additional vegetation may be lost by indirect effects associated with dust from gravel roads and pads, and from alteration of natural drainage flows resulting from development.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, overland moves by transport vehicles, and use of off-highway vehicles such as four-wheel vehicles and snowmachines, have likely caused the loss of less than 100 acres of vegetation in the NPR-A. In most cases, loss of vegetation would be temporary, lasting only a few years. Where Caterpillar or similar tractors have been used, or the vegetation has been bladed, vegetation scars persist to this day. An estimated 250 acres of tractor trail/tundra scars were created before 1973; about 50 acres were evident 30 years later (National Research Council 2003).

Former Distant Early Warning-Line Stations and the adjacent active and inactive Air Force Radar Sites, other military facilities, villages, public roads, airstrips, and other non-oil and gas infrastructure have been developed using gravel pads or on bare ground cleared of vegetation. The six North Slope villages north of the Brooks Range crest (excludes Point Hope) and west of the Canning River (excludes Kaktovik) are subdivided into tracts which total 7,128 acres. Not all of this acreage, however, has been directly affected by human use. Approximately 2,500 North Slope acres total (1,800 acres of village and public facilities, and 700 acres of military facilities) have been directly impacted, with another 4,630 acres of village area indirectly affected by human activities off gravel roads and pads, and this loss of vegetative cover is likely to persist into the indefinite future.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration Drilling. Much of the Arctic Coastal Plain and foothills has been surveyed since 1940, and vegetation was disturbed to varying degrees depending upon the soil and vegetation type, vehicle type, operator vigilance, and amount of snow cover. Studies of seismic and camp-move trails created on the eastern part of the North Slope in the 1980s showed that only 3 percent of seismic trails were still evident 8 years later, and none of this area showed moderate to high impacts. Yet 10 percent of camp-move trails still showed minor and 5 percent showed moderate to high disturbance (Jorgenson et al. 1996). This compared to values of 11 percent little to no impact, 64 percent minor, 23 percent moderate and 2 percent high on seismic trails just one to two summers following the activity, and 22 percent, 52 percent, 24 percent and 2 percent, respectively, for camp-move trails. The greatest damage occurred where the vegetative mat was destroyed and the underlying soil was exposed. This resulted from tracked vehicles or sleds on skids cutting into hummocks, or from Caterpillar operators making a tight turn and dropping the blade too deeply into the snow. As noted above, about 50 acres of tractor trail/tundra scars persist today from even earlier work.

Use of newer technologies, including vehicles that apply less pressure to the ground and restricting travel to periods when there is adequate snow and frost cover to protect vegetation, has reduced the level of impacts to vegetation. In 2001, a study conducted in the summer following seismic work found little to no impacts to tundra under seismic lines on 30 percent of the plots studied (versus 11 percent above; Jorgenson et al. 2003). Minor impacts were found on 66 percent (versus 64 percent above) and moderate impacts were found on 4 percent of the plots (versus 23 percent above); no plots were highly impacted (versus 2 percent above). Camp move trails in this study had little or no impacts on 18 percent, minor impacts on 54 percent, moderate impacts on 29 percent, and high impacts on none of the plots (similar numbers to the above study). This study suggests that improvements in the equipment and procedures used for seismic surveys have reduced the amount of impact to tundra, resulting in a higher percentage of tundra in categories of low or little to no impacts and few, if any, highly impacted sites. However, no significant improvement in camp-move technology is evident. Longer-term studies are needed to determine if these impacts persist for more than a few years and if they accumulate.

Other sources of vegetative loss include exploration-drilling sites with gravel pads, disturbed areas around these pads, exploration airstrips, and peat and gravel exploration roads. Based on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (National Research Council 2003), in 2001, approximately 1,700 acres had been impacted by these sites in the past, and 1,130 acres of disturbance were still evident. Most of these sites were developed before 1977, thus their effects on the vegetative landscape have persisted for decades and are likely to persist for several more decades. Over 500 acres of peat roads still showed evidence of disturbance, even though most of these roads were constructed over 30 years ago and used for only one to a few years.

Oil and Gas Infrastructure. Gravel roads and pads and gravel mines have caused the direct loss of vegetation, and also led to the indirect loss of vegetation and soil from thermokarst and alteration of natural drainage patterns. For the North Slope as a whole, it is estimated that by 2001 gravel had been used to construct about 8,998 acres of roads and pads in the oil fields, 564 acres of the Dalton Highway (North Slope portion only), 1,765 acres had been impacted by other oil field related disturbances, and gravel mines had impacted another 6,364 acres (Table 4-41 on page 58). Some gravel mines and pads have been rehabilitated (National Research Council 2003), but rehabilitation of gravel mines produces primarily fisheries habitat, not tundra vegetation, and rehabilitation of gravel pads has produced mixed results that have not restored areas to original conditions. Thus, direct impacts to vegetation by 2001 persist on about 17,691 acres (Table 4-41). It is assumed that the total growth in oil/gas footprint through 2012 will add another 462 acres of impact, for a total of 18,153 acres,

Construction of gravel pads, roads, and airstrips has altered the moisture regime of tundra near the structure by changing natural drainage patterns and areas where snow accumulates. Snowdrifts caused by gravel structures have increased the wintertime soil surface temperature and increased thaw depth in soils near the structures. These impacts have been exacerbated by dust deposition and by the formation of impoundments. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003).

The passage of vehicle traffic over gravel pads and roads results in dust and gravel being sprayed over vegetation within about 30 feet of the pad or road, and a noticeable dust shadow out to 150 feet or more. Within 30 feet of gravel structures, the dust and gravel can smother vegetation if traffic is heavy enough. The effects of dust on vegetation include early snowmelt, reduced soil nutrient concentrations, lower moisture, an altered soil organic horizon, and higher bulk density and depth of thaw (Everett 1980, Walker and Everett 1987, Auerbach et al. 1997). These studies found that plant species richness was reduced near gravel structures, particularly in naturally acidic soils. A decrease in acidophilus mosses, some lichen species, and certain heath taxa altered species composition (Walker and Everett 1987). In areas that experience heavy dust fallout, native plant communities have been killed and replaced by early-successional colonizers and species more tolerant of the altered site conditions. The magnitude of these effects depends on the duration of dust exposure (i.e., traffic intensity) and the distance from the source. Traffic volume and speed are generally low on in-field roads, which have limited dust impacts to vegetation, but are higher along the Dalton Highway.

In addition to dust effects, hydrologic changes due to road-induced changes in surface flow can occur. In general, most changes in the plant community and soil around gravel structures would occur within 164 feet of the structure (Woodward-Clyde Consultants 1983). The ratio of spatial extent of indirect effects (roadside flooding, dust, debris, thermokarst) to spatial extent of direct effects (gravel fill) vary from 8.6:1 to 2.4:1 with an average of 6:1 (National Research Council 2003). This may be a conservative figure for general application since it was based on studies done primarily in heavily developed portions of the Prudhoe Bay oil field. Using it across North Slope oil facilities and the Dalton Highway in general would suggest that about 57,400 acres have been indirectly affected by gravel fill (8,998 acres gravel footprint + 564 acres, x 6; see Table 4-41 on page 58). These impacts are likely to persist as long as gravel fill remains and vehicle travel occurs on the pads and roads.

The material used for gravel fill can also impact vegetation near gravel structures. Saline material used as fill increases the salinity of water draining off or leaching through the structure. Increased salinity at a site could alter the species composition of the plant community in the immediate vicinity of the gravel structure, shifting the community toward one comprised of species that are more tolerant of saline conditions (McKendrick 2000).

Spills. Overall, the effects of small spills (less than 500 barrels) on vegetation have not accumulated on the North Slope because the spills have been small, cleanup and rehabilitation efforts have generally been successful (National Research Council 2003) and ecosystems have generally recovered (Jorgenson 1997). There have been 11 large spills on the North Slope, eight in the oil fields since 1985 (9,800 barrels) and three along Trans-Alaska Pipeline since 1977 (11,400 barrels). Vegetation recovery has erased the effects of all but the most recent of these.

Air Quality. The effects of air quality on vegetation near industrial facilities on the North Slope appear to be minimal (Kohut et al. 1994; NRC 2003), although few studies have been conducted. Air quality currently meets federal and State air quality standards. Based on the few studies that have been conducted, these standards appear to be sufficient to have protected vegetation on the North Slope, although impacts to lichens from SO_2 have been shown to occur at concentrations well below the 3-hour standard (USDOI BLM/Minerals Management Service 1998), and the protection these limits on emissions provide to lichen species have been questioned (National Research Council 2003).

Summary of Past and Present Impacts and Their Accumulation

Based on the above analyses, approximately 2,500 acres of direct impacts, and 4,630 acres of indirect impacts to vegetation from non-oil and gas activities persist today. By 2012, oil and gas activities will have caused approximately 17,921 acres of direct impacts, and 56,000 acres of indirect impacts to vegetation. Whether these impacts are associated with non-oil and gas residential, commercial or military development, or oil and gas activities, these impacts to vegetation are additive to future impacts and would be likely to persist for several decades or more.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities on the North Slope, including archaeological and paleontological digs, camps associated with scientific studies, recreational use and other activities, overland moves by transport vehicles, and use of off-highway vehicles such as four-wheel vehicles and snowmachines, would continue to cause the loss of minor amounts of vegetation. In most cases, loss of vegetation would be temporary, lasting only a few years. Former Distant Early Warning-Line Stations and the adjacent active and inactive Air Force Radar Sites, other military facilities, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future, and for villages, are likely to increase in size, causing the loss of additional vegetation. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to increase by about 2 percent annually, approximately doubling to 3,600 acres by the mid-21st century when human population may level off.

Oil and Gas Exploration Activities

Seismic Activities. To analyze the cumulative impacts of seismic surveys on the North Slope, BLM assumes that future activity will over time approximate the current average across the North Slope. Based on these assumptions, approximately 86,400 acres of vegetation would be disturbed annually throughout the North Slope west of the Canning River, with 125 acres of that total still showing moderate to high levels of disturbance a decade later.

Exploration Drilling. Other sources of vegetative loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. These have been replaced in recent years by ice roads, airstrips, and drilling pads to reduce costs and environmental effects of gravel construction (Johnson and Collins 1980, Hazen 1997). As a result, only a small amount of vegetation is likely to be effected in the long term by exploration sites and facilities.

Oil and Gas Development Activities

Overview. Development activities that could contribute to cumulative effects to vegetation on the North Slope include oil and gas development in the NPR-A (analyzed under all alternatives); construction of a road and pipeline(s) between Umiat and the

Dalton Highway; offshore development in the Chukchi Sea; offshore development in the Beaufort Sea; construction of commercial gas pipelines to transport North Slope gas to southern markets; conventional oil and gas development in the area between the Colville and Canning rivers; and unconventional oil and gas production in that same area. All of these activities involve construction of infrastructure that would destroy vegetation within the immediate footprint of the project and indirectly affect vegetation through dust, flooding, changes in natural drainage patterns, snow drifting, increased water and air pollution, oil and chemical spills that could cause changes in the plant species composition and community types, possible gas releases accompanied by fire, and the potential for introduction of non-native invasive species.

Umiat Road and Pipeline. For this analysis, it is assumed that a road and pipeline(s) would be built from Umiat to the Dalton Highway with a length, depending on the route chosen, of up to 102 miles. The footprint of the road and ancillary facilities would be almost entirely outside of the NPR-A and is estimated at 850 acres (Table 4-40 on page 45) with material sites impacting an additional 175 acres. An oil pipeline along the same route would add up to 2 acres of direct impact footprint from the placement of vertical support members. A gas pipeline would be buried and would affect about 185 acres (trench and temporary spoils storage) for the long-term through trenching and temporary storage of spoils, while another 620 acres (ice road for pipeline construction) would receive short-term impacts from construction of an ice road.

Chukchi Sea Development. Potential onshore facilities to support offshore development in the Chukchi Sea include a staging base, a drilling waste disposal facility, a pump station, a gas compressor station, administration, maintenance and housing infrastructure, marine dock, airstrip and connecting roads. If built, these would probably be within the outer boundary of the NPR-A, but may be on native corporation lands at Wainwright. If a pipeline is built east across the NPR-A and on to Trans-Alaska Pipeline System, covering about 300 miles, it would add little long-term impacts to vegetation. Total acreage affected by gravel placement for all these facilities is estimated to be less than 100 acres, with another 20 acres of material sites. However, if a road were to be built along the pipeline route, the total impact may add up to 3,000 acres. Another 11,930 acres along the road would be affected by dust and moisture regime changes. Furthermore, a pipeline across the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in acres of vegetation affected in the NPR-A (i.e., it could total more than the currently assumed acres from the NPR-A development scenario and the Chukchi Sea development scenario). However, there are too many uncertainties involved with this to estimate acreage of impacts at this time.

Beaufort Sea Development. Offshore development in the Beaufort Sea would require onshore processing facilities only if offshore platforms were too far from the coast for transport of multi-phase produced fluids to shore. Regardless, up to 85 miles of onshore pipelines would be required, affecting less than one acre of total vegetation through vertical support member placement. If the BLM chooses Alternative B-1 of this plan, it would preclude development along the entire length of the NPR-A coast from Barrow to the Nuiqsut owned lands just west of the Colville River. The economic possibility of development in that portion of the Beaufort would be greatly reduced. Alternatively, if oil is developed in this region of the Beaufort and this plan allows it to come ashore in the NPR-A (possible under Alternatives A, B-2, C and D), the distribution system from there to Trans-Alaska Pipeline System may make smaller oil and gas fields in the northeastern NPR-A more economical. This may provide a synergism resulting in greater production from that portion of the NPR-A than foreseen under the plan's scenarios.

Commercial Gas Pipelines. Construction of gas pipelines could have long-term effects on up to 4,500 acres of vegetation, and pipeline operation after construction might affect only half that many acres. Both of these are likely overestimates since they assume impacts to 100 percent of 200-foot construction rights-of-way and 100 foot permanent rights-of-way, respectively. Actual gravel footprint is estimated at only 350 acres, with an additional 35 acres of new material sites. All of this would likely occur to the east of the NPR-A. A much greater impact to vegetation resources from this pipeline would be the area affected by the gas development that a pipeline would make possible (already analyzed under all alternatives). Without this pipeline to carry gas to market, it is unlikely that any of the foreseen gas development in the NPR-A scenarios would ever be built.

Conventional Oil and Gas Development between the Colville and Canning Rivers. The increase in area disturbed by oil and gas development on the North Slope has slowed in recent years. From 1968 to 1988, the oil field road network expanded east and west out of Prudhoe Bay and grew by about 24 road-miles per year, but only 3 road-miles per year since 1988. The average rate of all gravel placement was about 421 acres per year before 1988, and only 42 acres per year between 1988 and 2001 (National Research Council 2003; Table 4-38 on page 22). If the current rates continue into the future for areas east of the NPR-A, and the ratio of gravel mine acres to gravel footprint acres remains about 5:1, about 3,750 additional acres would be covered by gravel for construction of pads, roads and airstrips and 750 acres would be impacted by gravel mines through the year 2100. Approximately 27,000 acres would also be indirectly affected by dust, changes in hydrology, and thermokarst, using the 6:1 ratio for these indirect effects to direct effects (National Research Council 2003).

Unconventional Oil and Gas Development between the Colville and Canning Rivers. There are many challenges to this type of development on the North Slope, but for this cumulative analysis it is assumed that unconventional oil and gas development will become viable on better drained lands south of Prudhoe Bay and near the Dalton Highway. It is further assumed that this development will result in 200 acres of new gravel pads and roads, 40 acres of new or expanded material sites, and approximately 1,440 acres of dust and moisture regime changes each year for 15 years. After 15 years, it is assumed that any new gravel expansion due to unconventional oil and gas development will be part of the 42 acres per year described above for conventional oil and gas development. This would result in a total of 3,600 acres of additional vegetation destruction over 15 years to the cumulative total, and approximately 21,600 acres of vegetation change through dust and moisture regime changes.

Spills and Gas Releases. The amount of oil produced on the North Slope under the reasonably foreseeable future scenario is likely to continue to trend downward. As oil production slows, coupled with improvement in spill prevention and control technologies and training, the potential for effects to vegetation should decline over time. However, this trend could be countered by an aging pipeline system if that could lead to an increase in pipeline leaks (a countervailing effect).

The number of large spills (more than 500 barrels) on the North Slope between 2012 and 2100 is assumed to be 20 (Table 4–10 in Volume 2), one of which would occur as a result of development in the NPR-A. Large spills could occur at any time of year, and over any form of land cover. The result is a high variability in amount of land affected by each large spill. Large spills are relatively rare. That fact combined with the high variability of areal extent, means there are insufficient data to estimate an average area covered with any reasonable confidence. For the purpose of this analysis, it is assumed that all of these spills would reach the tundra, but the number of acres of tundra vegetation affected is not estimated.

Any accidental gas releases that occur in the future would affect vegetation only if the gas ignites and burns. The effects to vegetation would be localized, and significant recovery would occur within a few years (Racine et al. 1987). Impacts to tundra vegetation from gas releases would not accumulate.

Non-native Invasive Plant Species. No non-native invasive plants have been documented in the current oil fields, although some occurrences have been documented along the Dalton Highway. That may be because specific efforts have not been made to detect their presence in the oil fields. All of the above development scenarios for oil and gas and pipelines to transport them provide potential opportunities for the introduction and spread of non-native invasive plants to the various regions of the North Slope. This would represent a change to the current plant species composition that could accumulate with changes that directly result from development.

Air Quality. Emissions on the North Slope are expected to decrease as the result of an overall downward trend in oil production. Greater reliance on technologies that reduce the need for permanent roads and pads, and reduce the size of the facility footprint, also would result in lower levels of particulate matter emissions. Still, impacts to vegetation from past and future air pollutants could accumulate.

Abandonment. To date, very little abandonment has occurred on the North Slope. When to abandon any gravel pad, road, airstrip, or material mining site is an economic decision made by the company(ies) using and maintaining that facility. The North Slope presents special technical challenges to restoration and recovery. Extremely cold temperatures, meager precipitation (5 to 7 inches per year), and the short growing season lengthen recovery times substantially beyond those possible elsewhere in the United States. Natural recovery of disturbed sites to original soil and plant conditions has been estimated to require 600 to 800 years for upland sites and 100 to 200 years for marsh sites (Alaska Oil and Gas Association 2001).

Recovery of disturbed sites on the North Slope is complicated by the fact that any disturbance of the insulating vegetative mat can melt the underlying permafrost, a process that is extremely difficult to reverse and that can continue long after the initial disturbance ends. In addition, gravel pads and roads, which account for the vast majority of the directly affected habitat on the North Slope, retain moisture and nutrients poorly and thus slow recovery processes. Finally, the effects of climate change may make reclamation to the original plant community impractical or impossible, so this must be accounted for in reclamation plans.

Recovery times in the Arctic, as elsewhere, depend in part on the nature and extent of disturbance and the type of habitat affected. For example, wet sites tend to recover quickly from light oil spills; dry sites affected by diesel fuel spills recover exceedingly slowly, with little recovery occurring after several decades (Walker 1996). Disturbed areas that would recover relatively quickly in more temperate climates (such as those caused by Caterpillar tractor tracks), can persist for many decades because of melted permafrost. Reclamation of oil fields, even over a long period of time, would reduce some of the cumulative effects of vegetative loss.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Impacts from ice road, ice pad and ice airstrip construction would occur on 232,710 to 458,003 acres during the life of the plan; these impacts to vegetation would be short term and would not accumulate. Long-term impacts to vegetation from seismic surveys in the NPR-A would occur on approximately 1,490 acres under Alternative A, 1,670 acres under either Alternative B-1 or Alternative B-2, 2,453 acres under Alternative C, and 2,658 acres under Alternative D. Development in the NPR-A could directly cause long-term impacts on approximately 9,902 (A), 7,505 (B-1), 8,402 (B-2) 15,311 (C), and 16,329 (D) acres, and indirectly impact 29,301 (A), 20,734 (B-1), 23,596 (B-2), 39,062 (C), and 43,574 (D) acres of vegetation for Alternatives A through D, respectively. Indirect impacts may include the potential for the introduction and spread of non-native invasive species. Both direct and indirect impacts would be long-term and would accumulate. Total, long-term, direct and indirect impacts to vegetation from exploration and development combined would occur on 0.12 percent (Alternative B-1) to 0.26 percent (Alternative D) of the NPR-A.

The impacts in the NPR-A would increase the total amount of vegetation on the North Slope impacted by all oil and gas development, and generally would be additive in nature. Exceptions may occur in relation to development in the offshores of the Chukchi and Beaufort seas. Depending on oil prices and where and how much oil is ultimately developed offshore, there could be synergistic effects on acreage of vegetation affected in the NPR-A. This would occur if a discovery(ies) in the offshore and related facility development onshore would make the development of an oil field in the NPR-A economically feasible. This potential scenario for synergism is less likely under Alternative B-1 because the NPR-A coastline of the Beaufort Sea would be protected from having infrastructure cross it, although the Chukchi coast would still be open to pipelines coming ashore.

Synergism could similarly result if development (e.g., pipelines) near the NPR-A coastline of the Beaufort Sea resulted in offshore development being more economically feasible. Such offshore development may result in additional vegetation impacts from developments built onshore (e.g., staging base, processing facility, etc.), probably also near the coast, in support of the activities offshore. This scenario is unlikely under Alternative B-1, since offshore infrastructure would not be allowed to connect to the coast under this alternative. It would be most likely under Alternative D, which has the least constraints to development onshore.

Conclusion

The area of vegetation impacted by oil and gas exploration and development, compared to the amount of available habitat on the Arctic Coastal Plain in Alaska and on the North Slope as a whole, is relatively small. The five alternatives differ in the acreage of vegetation that would be impacted. Alternative B-1 would contribute the least to cumulative vegetation loss across the North Slope and Alternative D would result in the greatest loss of vegetation.

In summary, impacts to vegetation will accumulate from the following sources: past non-oil/gas activities, non-oil/gas activities from now until 2100, past oil/gas activities outside of the NPR-A, future conventional and unconventional oil/gas activities outside of the NPR-A through 2100, future oil/gas activities in the NPR-A, future oil/gas activities in the Chukchi and Beaufort seas, construction of commercial gas pipelines, and construction of a road and pipeline(s) between Umiat and the Dalton Highway. All future impacts are additive to the impacts to vegetation that have accumulated in the past and persist today. In a few cases as described above, however, future impacts may have a synergistic effect on cumulative vegetation impacts.

Climate change may eventually lead to far larger shifts in the composition of Arctic tundra toward increased shrub height and cover extent, tree encroachment north of the Brooks Range and increased grass and sedge species (Chapin et al. 1995; Naito and Cairns 2011; Sturm et al. 2001; Walker et al. 2006; Scenarios Network for Alaska Planning 2011). These increases would likely be at the expense of lichen and moss cover (Chapin et al. 1995, Cornelissen et al. 2001, Jorgenson and Buchholtz 2003, Epstein et al. 2004, Walker et al. 2006, Jandt et al. 2008). In addition, warmer soil temperatures are likely to increase thermokarst, and increases in sea level may inundate low-lying tundra areas, increasing salt marsh, aquatic, and wet tundra vegetation types and erosion of coastal bluffs (Arctic Climate Impact Assessment 2004). Such impacts of climate change could accumulate with any changes in soil thermal regimes that might occur as a result of past and future non-oil and gas and oil and gas activities in and near NPR-A, potentially leading to synergistic impacts to vegetation.

4.8.7.6 Wetlands and Floodplains

In compliance with Executive Order 11990, Protection of Wetlands and Executive Order 11988, Floodplain Management, BLM has prepared a cumulative impact analysis on those areas within the NPR-A that are considered to have the function and value of wetlands and floodplains, as described in section 3.3.2 (Volume 1), "Wetlands and Floodplains." Approximately 95 percent of the NPR-A would be considered wetlands according to established criteria for determining wetland status. It is likely and therefore assumed that all ground-disturbing actions will be impacting wetlands for the purposes of calculating cumulative impacts. Cumulative impacts to wetlands are also described within section 4.8.7.3 "Soil Resources", and section 4.8.7.5, "Vegetation." Cumulative impacts to floodplains are also described within the "Vegetation" section and in section 4.8.7.4, "Water Resources and Water Quality."

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Activities not related to oil and gas exploration, including scientific excavations, temporary tent camps associated with scientific studies, recreational use, hazardous material or debris removal, legacy well plugging, small fuel spills, overland moves by transport vehicles, and use of off-highway vehicles such as four-wheel vehicles and snow machines have likely caused impacts to wetlands on less than 100 acres in the NPR-A. In most cases where vegetation has been compressed or disturbed, impacts would be temporary, lasting only a few years.

Former Distant Early Warning-Line Stations and the adjacent active and inactive Air Force Radar Sites, other military facilities, villages, public roads, airstrips, and other non-oil and gas infrastructure have been developed using gravel pads or on bare ground cleared of vegetation. The six North Slope villages north of the Brooks Range crest (excludes Point Hope) and west of the Canning River (excludes Kaktovik) are subdivided into tracts which total 7,128 acres. Not all of this acreage, however, has been directly affected by human use. Approximately 2,500 North Slope acres total (1,800 acres of village and public facilities, and 700 acres of military facilities) have been directly impacted, with another 4,630 acres of village area indirectly affected by human activities off gravel roads and pads, and this loss of vegetative cover is likely to persist into the indefinite future.

Activities Associated With Oil and Gas Exploration and Development

Seismic Activities and Exploration. Much of the NPR-A has been surveyed since 1940, and wetlands have been disturbed to varying degrees depending upon the soil and vegetation type, vehicle type, operator vigilance, and amount of snow cover. The greatest damage occurred where the vegetative mat was destroyed and the underlying soil was exposed. This resulted from tracked vehicles or sleds on skids cutting into hummocks, or from Caterpillar operators making a tight turn and dropping the blade too deeply into the snow. Where tracked vehicles have been used, or the vegetation has been bladed, scars in the vegetation persist to this day. An estimated 250 acres of tractor trail/tundra scars were created before 1973; about 50 acres remain evident today (National Research Council 2003). Use of newer technologies, including use of vehicles that apply less pressure to the ground and restricting travel to periods when there is adequate snow and frost cover to protect vegetation, have reduced the level of impacts to vegetation and soil.

Oil and Gas Infrastructure. Peat and gravel roads and pads, and gravel mines have caused the direct loss of wetlands and also led to the indirect loss of vegetation from thermokarst and alteration of natural drainage patterns. Through 2001, over 500 acres of peat roads still showed evidence of disturbance, even though most of these roads were constructed over 30 years ago. Calculated through the year 2011, gravel has been used to construct over 9,500 acres of roads and pads, while gravel mines have impacted another 6,400 acres on the North Slope. Total impacts to wetlands through 2011 from peat and gravel roads and pads, gravel mines, and other areas are approximately 18,400 acres.

Construction of gravel pads, roads, and airstrips has altered the moisture regime of tundra near the structure by changing natural drainage patterns and areas where snow accumulates and introducing dust. Snowdrifts caused by gravel structures have increased the wintertime soil surface temperature and increased thaw depth in soils near the structures. These impacts have been exacerbated by dust deposition and by the formation of impoundments. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003). Cumulative impact research found that the ratio of direct to indirect impacts from gravel structures such as roads was about one to one (National Research Council 2003). If so, the condition of an additional 18,400 acres of vegetation may have been altered due to hydrologic changes on the North Slope. Based on this information, the total of direct and indirect long-term impacts to wetlands from past and present oil and gas activities on the North Slope covers approximately 36,800 acres.

Recent technologies, including roadless development, horizontal drilling, and closer spacing of wells on pads, and a slowing of oil field development, have greatly reduced the amount of surface disturbance needed to develop and produce oil. As a result, the annual amount of surface disturbance associated with gravel roads and pads has slowed substantially during the past two decades and reached a total of approximately 9,500 acres by 2011. Approximately 1,400 culverts and 17 bridges have been installed in association with over 400 miles of oilfield roads (excluding the Dalton Highway) through 2001. Streambank erosion, scour and sedimentation has occurred within floodplains at stream crossings due to inadequate design in the placement of structures, culverts, or bridges. This has altered natural sediment transport and deposition, creating scour holes or channel bars and impounding water.

Spills. Overall, the effects of spills on wetlands and floodplains have not accumulated on the North Slope because all but two of the spills have been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003). The largest spill in the North Slope oilfields (over 200,000 gallons) occurred in March of 2006; it is likely that some wetlands were damaged during the previous and ongoing clean-up and remediation efforts.

Summary of Past Effects and Their Accumulation

Based on the above analysis, approximately 2,500 acres of direct impacts to wetlands from non-oil and gas activities persist today. Oil and gas activities have caused approximately 18,400 acres of direct impacts to wetlands that persist today; another 18,400 acres of indirect impacts have also occurred, some of which persist today. Since most of these impacts are associated with ongoing non-oil and gas residential and commercial development, and oil and gas activities, these impacts to wetlands are additive to future impacts and would be likely to persist for several decades or more. However, the rate at which vegetation is disturbed by development has slowed substantially in recent years due to advances in technology and a slowing of oil field development on the North Slope.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities described in section 4.8.2 will continue to have minor impacts on wetlands and floodplains. It is anticipated that villages will continue to grow in the future due to population growth and to provide services and infrastructure to support new oil and gas development on the North Slope. The amount of area that would be disturbed by new development is projected to increase by 2 percent annually for the next 40 years and then level off. Assuming community infrastructure and footprint grow at roughly the same pace as population, there would be approximately 3,600 acres of community footprint by the time population is expected to level off in the mid-21st century.

Although not part of the development scenario for the NPR-A, it is reasonably foreseeable that the State of Alaska would build a new road from the existing oil fields or the Trans-Alaska Pipeline System to the NPR-A. One proposal is to build a road from the Spine Road to Nuiqsut. Another proposal is to build a 100 mile road from the Trans-Alaska Pipeline System to the NPR-A which would be entirely outside the NPR-A.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. It is possible that up to 16 seismic surveys would take place under Alternative D if maximum development occurred, impacting up to approximately 786,603 acres in the next 30 years, resulting in long-term disturbance (greater than 8-9 years) of 2,658 acres. These impacts would accumulate and be additive to past effects to wetlands on the North Slope. Vegetation recovery studies have shown that most impacts to vegetation from seismic activities and exploration should be minor and short term (National Research Council 2003).

Oil Development and Production. Future development and production could occur on the North Slope in NPR-A, the Chukchi and Beaufort Seas, and onshore between NPR-A and Arctic National Wildlife Refuge. New development, especially for economically marginal fields of oil, would most likely occur near existing fields so that infrastructure systems could be shared. Additional long-term impacts to wetlands and floodplains would occur as a result of this development.

Oil and gas development and operation would cause the following long-term impacts: affect wetlands by burial of vegetation under gravel pads, gravel roads, and gravel airstrips; excavating gravel at mine sites; constructing vertical support members for elevated pipelines; and excavating trenches for buried pipelines. Construction of gravel pads, roads, and airstrips could also result in indirect effects by altering the moisture regime of vegetation near the structures due to dust and snow accumulation and modification of natural drainage patterns. These factors could combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures. This can result in approximately one acre of indirect impacts to vegetation for each acre of direct impact (National Research Council 2003). Changes may also occur over time to habitat continuity, driving out more sensitive, interior species, and providing habitat for hardier opportunistic and non-native species in wetlands.

Under Alternative D, which opens the entire NPR-A to oil and gas development, long-term direct impacts to wetlands and floodplains could occur on approximately 31,300 acres. In addition, approximately 10,750 acres of gravel mines would be needed for development for a total of approximately 42,050 acres. Assuming a one to one ratio for direct-to-indirect impacts, long-term impacts could total approximately 84,100 acres of vegetation disturbed by the gravel footprint from future oil and gas development on the North Slope.

Offshore development associated with leases in the Beaufort and Chukchi Seas could impact small areas along the coast for staging and storage of materials. Similarly, development in the Chukchi Sea could require a pipeline across the NPR-A. However, long-term impacts to vegetation from elevated pipelines are mainly associated with vertical support members that create only small areas of vegetation disturbance. Additional areas of vegetation would be impacted if some buried pipelines were required.

Additional development and production could also occur east of the NPR-A, between the NPR-A and Arctic National Wildlife Refuge. This analysis assumes that most of the estimated undiscovered oil in the area would be brought into production in the foreseeable future. No estimates are currently available for the amount of additional infrastructure needed to produce this oil or gas, if a gas pipeline is constructed to deliver North Slope gas to markets. However, production would likely use a combination of existing infrastructure and new infrastructure resembling the Alpine field. Although the footprint would be relatively small compared with the total area, some additional areas of long-term disturbance to vegetation would be required for gravel staging areas, gravel roads, gravel pads, and other semi-permanent infrastructure.

Trenching to bury gas pipelines, both one from the North Slope to outside gas markets, and pipelines on the North Slope to bring gas to the beginning of that market pipeline, would alter the soil profile for all the area excavated. Based on estimates of disturbance associated with burying pipeline in the NPR-A and extrapolating that very roughly to other areas, it is estimated that approximately 2,485 acres of vegetation would be disturbed by being excavated to bury gas pipelines in the NPR-A. An additional area would be disturbed by equipment and temporary overburden storage in the course of burying the pipelines. Assuming a one to one ratio of direct to indirect impacts from buried pipelines, a total of 4,970 acres could be impacted by construction of future gas pipelines on the North Slope.

The total future direct and indirect impacts to wetlands and floodplains resources from future oil and gas development on the North Slope would be the sum of impacts from the gravel footprint, excavation of material sites, and construction of elevated and buried pipelines described above. Therefore, the total area of long term impacts to wetlands from future development would be approximately 47,020 acres. These impacts are additive to the 39,300 acres already impacted from past and present oil and gas activities that persist today. Assuming a one to one ratio for direct to indirect impacts, a total of approximately 94,040 acres of wetlands could be impacted long term by gravel footprint from future oil and gas development in the NPR-A.

Oil Spills. Spills of refined oil could occur during overland moves and seismic surveys. These spills would likely be small, averaging 3 to 5 gallons or less, and would affect small areas. Contaminated snow would be cleaned up immediately upon discovery. Overall, past spills of this size and type on Alaska's North Slope have caused minor ecological damage and ecosystems have generally recovered, with wetter areas recovering more quickly than drier areas (Jorgenson 1997, McKendrick 2000).

Spills from production activities could involve crude oil, refined products, produced water or seawater. The extent of environmental impacts of a spill or gas release would depend upon the type and amount of materials spilled or released, the location of the spill or release, and effectiveness of the response, since spill cleanup is also likely to damage vegetation. Oil-spill cleanups would mitigate impacts on soil and vegetation as long as cleanup methods and operations were carefully controlled and minimized surface disturbance. The area affected would be limited to the area immediately adjacent to and covered by the spill. The majority of small spills would be contained on the gravel pad and would have no impact on vegetation.

Oil spills on wet tundra kill the moss layers and aboveground parts of vascular plants, and sometimes kill all macroflora at the site (McKendrick and Mitchell 1978). Damage to oil-sensitive mosses could persist for several years if the site were not rehabilitated. The length of time a spill would persist would be dependent upon soil moisture and the concentration of the product spilled. Overall, past spills on Alaska's North Slope have resulted in minor ecological damage and ecosystems have shown good potential for recovery because most of the habitat is wet (Jorgenson 1997).

The projected increase in activity levels combined with the potential problem of aging pipelines could result in more spills. However, the recent large spill in March 2006 caused by pipeline corrosion may lead to better overall maintenance, oversight, and prevention of potential problems that can lead to spills. Overall, the effects of spills on vegetation have not accumulated on the North Slope because the spills have generally been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003).

Abandonment. As more oil and gas development and production occur on the North Slope, the more need there will eventually be for removal of infrastructure and rehabilitation of vegetation. Removal of aboveground facilities, pipelines, bridges, and power poles would have a minor impact on vegetation. Roads and pads will remain unaffected if they are maintained, but once maintenance ceases, thaw subsidence in ice-rich areas could result in settling of the gravel structures into thermokarst troughs.

Removal of the roads and pads would accelerate thaw subsidence, but would also accelerate the reclamation process. Removal of gravel fill has recently been done in wetlands, and preliminary studies suggest that wetland mosaics of vegetation can be restored, although the method is expensive and finding acceptable locations for the fill can be difficult. Open-pit gravel mine rehabilitation typically involves converting mine sites to wetlands, including lakes, with a channel usually cut between the pit and a stream or river so the site can be accessible to fish. Such sites create potential overwintering habitat for fish, but they also result in the permanent loss of the original habitats. Reclamation of oilfields would reduce some of the cumulative effects of wetlands loss.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

There could be synergistic effects on acreage of affected wetland vegetation that would occur if a large discovery in the Chukchi Sea made development possible of other oil fields, which would not have been economically viable.

Synergism could similarly result if development in the NPR-A north of Teshekpuk Lake resulted in offshore development being more economically feasible. Such offshore development would likely result in additional wetland vegetation, soil, and water impacts from developments built onshore in support of the activities offshore. This would most likely affect the northern portion of the NPR-A or the Beaufort Sea coastal portions of the northeastern portion of NPR-A. This scenario is very unlikely to occur under Alternative B-1 because new non-subsistence infrastructure would not be allowed along much of the coast east of Barrow. Such synergistic relationship between Beaufort Sea offshore development and onshore development in NPR-A also is reduced under Alternative B-2 because very little coastal area in the NPR-A east of Barrow would be available for lease. It would be most likely under Alternative D because of fewer development constraints.

Impacts to floodplains could occur from river channel crossings by pipelines and roads, which could destroy vegetation where bridge pilings or vertical support members were required for the crossing. Construction of a buried gas pipeline or an oil or gas pipeline under a river channel would also have impacts to floodplain vegetation in portions of the floodplain where the pipeline was buried. Alternative D would likely result in the greatest impacts, since additional river crossings would probably be necessary. The likelihood of buried river crossings (or possibly of buried gas pipelines) would also increase. These impacts would be additive with impacts from other developments occurring on the North Slope.

Conclusion

Cumulative impacts to wetlands and floodplains from non-oil and gas activities on the North Slope are relatively small compared to those from oil and gas development and have impacted approximately 2,500 acres. Assuming community infrastructure and footprint grow at roughly the same pace as population, there would be approximately 3,600 acres of community footprint by the mid-21st century (see section 4.8.2.1). In addition, approximately 700 acres of vegetation impacted by former Distant Early Warning Line stations as well as the adjacent active and inactive Air Force radar sites are expected to persist. Therefore, the total long term cumulative impact to wetlands on the North Slope from non-oil and gas activities (past, present, and foreseeable future) would be approximately 4,300 acres.

The total of direct and indirect, long-term impacts to wetlands and floodplains from past, present and future oil and gas activities on the North Slope will impact approximately 133,340 acres. Impacts to wetlands from future oil and gas development include exploration activities and construction of gravel pads, gravel roads, gravel airstrips, gravel staging areas, excavation of material sites, oil pipelines, and possible gas pipelines (both to market outside the North Slope and within the North Slope). The duration of the impacts would range from short term (less than 1 to 5 years) if the vegetation was lightly disturbed up to several decades or longer if the vegetation was covered by gravel, removed, or permafrost was thawed creating thermokarst. Impacts associated with exploration and development activities in the NPR-A would be additive with impacts from past activities in the NPR-A and across the North Slope.

If global climate change persists, the cumulative effects to wetlands and floodplains from oil and gas development, and non-oil and gas development, on the North Slope could be greater than predicted. If the climate warms, the permafrost will thaw to an increased depth each season, which will cause varying degrees of impacts on subsidence, soil moisture, and vegetation. However, if the permafrost continues to warm, its ability to support structures would diminish, which could affect development on the North Slope. Thicker gravel may be needed to support structures, and abandoned work pads and roads could become unusable as they are cut up by deep polygonal troughs over thawing ice wedges, or by other thermokarst degradation. The potential for many shallow streams, ponds, and wetlands in the Arctic to dry out under a warming climate is increased by the loss of permafrost. These shallow systems depend on snowmelt as their primary source of water, with rainfall gains often negated by evapotranspiration during the summer. Evaporation from these shallow water bodies is very likely to increase as the ice-free season lengthens. Hence, the water budget of most lake, pond, and wetland systems is likely to depend more heavily on the supply of spring meltwater from winter precipitation to produce a positive annual water balance, and these systems are more likely to dry out during the summer (Arctic Climate Impact Assessment 2004).

Impacts to floodplains could occur from river channel crossings by pipelines and roads, which could alter the natural drainage and stream channel and destroy vegetation where bridge pilings or vertical support members were required for the crossing. Construction of a buried pipeline for gas or for an oil pipeline under a river channel would also have impacts to floodplain vegetation in portions of the floodplain where the pipeline was buried. These impacts would be additive with impacts from other developments occurring on the North Slope. Nor do these figures take into account impacts from construction of a natural gas pipeline from the North Slope to market or burial of gas pipelines within the North Slope from new commercial gas developments. Additional wetland acreage would be disturbed through burial of gas pipelines that ultimately deliver gas to a conditioning plant and the gas pipeline that delivers gas from the North Slope. Revegetation along the route of these buried pipelines would occur over several years to decades, or even to over a century in some, usually dryer, areas.

4.8.7.7 Fish

This section discusses the potential cumulative effects on freshwater, anadromous, and marine fish that could result from management actions in the NPR-A.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Increased mechanization is the dominant factor in considering effects on fish in the NPR-A related to the development of six North Slope villages over the last several decades. Motorized watercraft, ATVs, and snowmachines have improved the ability to access subsistence fishing areas and the efficiency of fishing those areas. Fuels and industrial fluids associated with these activities have likely contributed to pollutant exposure in surface waters at a small scale. However, there is no evidence that harvesting fish in the NPR-A and its coastal waters or any related impacts have accumulated and affected the sustainable yield of the resource. Bountiful subsistence fisheries currently exist across the NPR-A (e.g., Kassam and WTC 2001; MJM Research 2007f; Moulton et al. 2010b). For instance, harvest rates for the lower Colville River Arctic cisco fishery from 2004 to 2006 were some of the highest observed during twenty years of monitoring (MJM Research 2005e, 2006c; personal communication with Larry Moulton 2007).

Military Distant Early Warning-Line stations had effects on fish in or near the NPR-A that included removing large areas of gravels and sand along the coast and contaminating local waters (Fritz 2010). Localized, acute impacts would have initially accumulated across the region during construction of the stations, especially considering that all 14 along the coast of the North Slope were built in a short time-span, between 1955 and 1957. However, while terrestrial impacts still persist, impacted aquatic habitat has likely been on a recovery trajectory since construction. Initially disturbed coastal habitat has had more than 50 years to stabilize and new coastal features would have formed by sand and gravel that was distributed in the vicinity by local currents and annual storms. Similarly, contaminated coastal waters from construction and operation would have largely flushed out of the area and during abandonment contaminated materials were primarily buried or stockpiled. Due to surrounding impermeable permafrost, extensive leaching is not likely; however, contaminated soils could erode into surface water in the future and negatively affect local fish habitat.

Other non-oil and gas activities that have taken place in the NPR-A and adjacent lands include recreation, hunting, and research and associated small camp, watercraft, and floatplane use; waste removal and remediation projects; and winter overland supply operations. Impacts on fish habitat, water quality, or fish survival from these activities would have been localized and temporary. Concentrated recreation and associated sport fishing along the Dalton Highway has impacted individual fish in rivers, streams, and lakes made accessible by this transportation corridor. However, sport fish management by Alaska Department of Fish and Game has mitigated potential impacts to the extent that they likely have not accumulated; fish harvest levels set by regulations are expected to be compensatory to natural mortality within populations, rather than additive.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Disturbance, physical injury, and mortality are the primary effects on fish associated with seismic surveys, as described in section 4.3.7.2 (Volume 2). Acute mortality from acoustic energy may be a problem primarily associated with explosive-based sources (Wright 1982, Cott et al. 2003). It is likely that earlier, explosive-based seismic surveys impacted fish, but the Alaska Department of Fish and Game (1991) standards for blasting near fish-bearing waters and the shift to Vibroseis-based surveys substantially reduced the potential for those impacts to occur. Impacts from winter seismic surveys in the NPR-A, even if fatal to fish, have probably been restricted to a number of discrete locations during one time period and have not accumulated. The previous use of airguns to conduct open-water seismic surveys in the NPR-A has been very limited (Teshekpuk Lake in 1974 and 1975) and, as a result, had no lasting effect. Impacts from coastal exploration with airguns in the Beaufort Sea are unknown (National Research Council 2003).

Historical oil and gas exploration activities (primarily before 1977) often consisted of constructing gravel pads, airstrips, and roads. This likely increased turbidity and sedimentation in local waters during construction activities and potentially included direct removal of gravel from streams. Although in 2001 disturbance was still evident on more than half of the 1200 acres initially utilized on the North Slope (National Research Council 2003), few impacts on fish and aquatic habitat would have occurred following the construction phase and up to several years afterwards due to possible impacts from surface runoff. Because of the brief temporal impact and the relatively sparse spatial extent of this exploration infrastructure, impacts likely did not accumulate.

More recent exploration has been conducted entirely during winter using temporary snow trails and ice roads, pads, and airstrips. The major potential impacts on fish from winter exploration are barriers to spring migrations caused by snow and/or ice “bridges” at channel crossings and the water use associated with building ice infrastructure. There is evidence that current breaching practices at snow and ice “bridges” are largely effective in allowing free fish passage (Whitman 2010), with only infrequent impacts at channel crossings. In the early years of exploration, water was obtained from any source, including rivers during winter. Bendock (1976) documented water withdrawals from the Sagavanirktok River that depleted water in wintering areas and increased mortality to fish in the area. However, water needed for more recent exploration was mainly supplied by lakes. Investigations into this practice have documented lake recharge in the spring and found no measurable change in dissolved oxygen caused by water withdrawals (Baker 2002; Hinzman et al. 2006; Baker 2007; Chambers et al. 2008; Holland et al. 2008). In a few isolated incidents, fish have been killed or injured around intake screens, but this has only occurred at a very small percentage of lakes being utilized as water sources. Given the improvement of water use practices associated with oil and gas exploration and the effectiveness of current guidelines, it is not likely that impacts on fish have accumulated.

Oil and Gas Development and Production. Roads and pads (including airstrips) constructed for oil and gas development on the North Slope can affect runoff patterns from small tributaries or wetlands that connect rivers, streams, and lakes. This can impact downstream habitat and interfere with fish migrations and access to preferred habitats both temporally and spatially, as described in section 4.3.7.2 (Volume 2). Between 1968 and 2001, over 6,000 acres of gravel pads and more than 500 miles of gravel road were constructed in association with oil-field development on the North Slope, with much of the gravel fill altering drainage patterns (National Research Council2003). During this time, nearly 1,400 culverts were installed on the North Slope (National Research Council2003) and recent investigations into these structures found that a number of crossings had problems that likely impair or impede fish passage (Morris and Winters 2004, 2007). The pads and roads associated with ongoing North

Slope oil and gas development have resulted in impacts on fish that have accumulated in the region.

Gravel mining necessary to build the development infrastructure can impact fish habitat and fish species suitability in downstream channels, as described in section 4.3.7.2 (Volume 2). Up until 1977, nearly 5,000 acres of river floodplains were utilized for gravel mines (National Research Council2003). Numerous examples of impacted stream morphology and effects on fish from this mining were cited by a U.S. Fish and Wildlife Service study (Woodward-Clyde Consultants 1980). As a result, the amount of new floodplain disturbance from gravel mining only increased by an additional 2 percent between 1977 and 2001 and additional mines since the early 1980s were predominantly placed in upland sites (National Research Council 2003). The mines placed in floodplains since then have been constructed and operated under more protective guidelines than previously utilized (Joyce et al. 1980; McLean 1993). A positive effect on fish can also result when abandoned floodplain gravel mines are flooded by a stream. This effectively creates deep pools suitable for fish overwintering and spawning, which has been well documented around current North Slope oil developments (Hemming 1988; Hemming et al. 1989; Roach 1993; Alaska Department of Fish and Game 2011a). While negative impacts on fish likely accumulated during the first 10-15 years of gravel mining in floodplains, the rate of these impacts has substantially reduced since then. According to the National Research Council (2003), the positive effects to fish that persist from gravel pits on the North Slope likely outweigh the negative effects.

Year-round freshwater use that occurs to support permanent domestic facilities can potentially reduce habitat quality, affect waterbody connectivity, and cause mortality or injury at intake devices, as described in section 4.3.7.2 (Volume 2). Unrestricted freshwater use in the early years of oil and gas development resulted in many fish mortalities (Bendock 1976). Since that time, freshwater demand has been supplied by regulated lakes and deep reservoirs created from abandoned gravel pits. The requirement to use Alaska Department of Fish and Game-approved low-velocity intake devices has also mitigated impacts on fish. Fish populations impacted more than three decades ago from unrestricted water use have likely recovered since those practices ended. With the effectiveness of current freshwater use guidelines (Baker 2002, Hinzman et al. 2006, Baker 2007, Chambers et al. 2008, Holland et al. 2008) and only isolated incidents of fish being injured or killed at intake devices, the impacts from year-round freshwater use have probably not accumulated.

A vast amount of seawater has been pumped from the Beaufort Sea to use for waterflooding of current North Slope production wells. Large intake pipes located at Prudhoe Bay, Endicott, and Kuparuk can remove up to 92.4, 11.6, and 25.2 million gallons per day, respectively (National Research Council 2003). Relative to freshwater use, the volume of seawater removed is not a concern regarding fish habitat, given the magnitude of the resource. However, fish entrainment, injury, or mortality at these high volume intakes has been a concern. Monitoring at the Prudhoe Bay and Kuparuk waterflood facilities from 1984 to 1987 found that few fish entered the bypass system and most that did were able to pass through (Dames and Moore 1985, 1986, 1987, 1988). Nevertheless, an exception was observed in 1985 when more than a million fish larvae of nine species were entrained at the Prudhoe Bay facility (National Research

Council 2003). Despite the problem in 1985, monitoring halted after 1987 when the intakes were determined to be largely functioning as intended. It is probable that seawater intakes have entrained fish at other times, but since the 1980s, monitoring confirmed that the systems were highly effective in mitigating impacts on fish; effects from waterflooding likely have not accumulated.

Causeways can block fish movements along the coast or alter coastal circulation and mixing patterns to the extent that temperature and salinity conditions become inhospitable for some anadromous and marine fish. The Prudhoe Bay West Dock and another major causeway in the Sagavanirktok River delta were built to support ongoing North Slope oil and gas developments. Monitoring between 1981 and 1987 determined that significant impacts had occurred to water quality, fish movements, and local fish community structure (Ross 1988). Retrofitted breaches were partially successful in reducing, but not eliminating, these impacts (National Research Council 2003). Findings from the many studies related to these North Slope causeways (e.g., Ross 1988, Colonell and Gallaway 1990, Fechhelm 1999, Fechhelm et al. 1989, 1999) indicate that effects on fish have been accumulating since their construction.

Overall, the effects of oil spills on fish have not accumulated on the North Slope because the spills have been small and cleanup and rehabilitation efforts have generally been successful (National Research Council 2003). The largest spill in the North Slope oilfields (over 200,000 gallons) occurred in March of 2006, but this resulted in essentially no impacts to fish due to the timing of the spill, which allowed cleanup to take place before the spring melt. No notable spills into the marine environment have occurred.

Summary of Past and Present Effects and Their Accumulation

Effects on fish to date from most North Slope non-oil and gas activities, such as developing villages, recreation, hunting, research, waste removal and remediation projects, and winter overland supply operations have been minor and localized. Impacts on fish from military Distant Early Warning-Line stations that initially accumulated along the coast have been recovering since abandonment.

Effects on fish from seismic activities and exploration over the last several decades should have largely been acute and short-lived. Explosive-based seismic surveys and exploration that included construction of gravel infrastructure have been replaced by Vibroseis-based surveys and winter exploration that utilizes temporary ice infrastructure, which have fewer potential repercussions on the environment. Aquatic habitats and local fish communities that were temporarily impacted in the past have likely recovered.

Some aspects of North Slope oil and gas development and production have caused effects on fish that have accumulated, while impacts on fish from other aspects have not persisted. Effects from gravel pads and roads as well as causeways have accumulated by impeding fish movements and significantly altering fish habitat by changing physical and chemical conditions. While floodplain gravel mining initially caused a similar suite of negative impacts, the positive effect of additional deep-water habitat created during mine abandonment is believed to offset those impacts. Year-round freshwater use for domestic facilities, seawater use for waterflooding, and oil spills have all effected fish in ephemeral ways that have not likely accumulated.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Effects on fish from Distant Early Warning -Line stations should continue to diminish over time if no new facilities are constructed and clean-up efforts continue. Other non-oil and gas activities that will take place in the NPR-A and adjacent lands related to village development; recreation, hunting, and research and associated small camp, watercraft, and floatplane use; waste removal and remediation projects; and winter overland supply operations will probably increase in the future. However, in most cases, minor impacts on fish would be localized and brief and would not accumulate.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Future seismic surveys in the NPR-A will presumably continue to occur during winter and chiefly utilize Vibroseis technology. Exploration drilling operations will continue to use temporary ice roads and snow trails for transportation corridors and temporary ice pads for camps and exploratory drilling. Based on evidence that these current techniques effectively mitigate impacts on fish, the localized impacts that could occur would not be expected to accumulate. Airgun-based seismic activities and exploratory drilling in the Chukchi Sea and Beaufort Sea could impact coastal marine fish as well as anadromous fish from the NPR-A, primarily due to disturbance. Nearshore operations would potentially impact more fish than offshore operations since many fish species tend to concentrate along the coast during much of the open-water season. However, acoustic noise from airgun arrays and exploration-related vessel traffic would be predominantly transient and would not typically occur in the same location with much frequency. Overall, effects on fish from seismic activities and exploration in the NPR-A, lands to the east, and in the Chukchi and Beaufort seas would not likely accumulate.

Oil and Gas Development and Production. The elements of onshore North Slope oil and gas development and production most likely to contribute to future effects on fish that could accumulate include permanent infrastructure (e.g., roads, pads, pipelines, and causeways) and gravel mining necessary to build the infrastructure. As demonstrated by existing development in the region, these activities are likely to continue contributing to changes in natural drainage patterns and water quality, alterations to physical habitat, barriers to fish movements, increased water pollution, and oil spills. Oil and gas development and production to the east of the NPR-A, whether conventional or unconventional techniques are used, would require additional facilities and infrastructure that would be additive to impacts from NPR-A development. A road and pipeline connecting Umiat with the Dalton Highway would increase the likelihood of additional impacts to the east of and within the NPR-A. This road to Umiat could also lead to synergistic pressures on fish in the Colville River and its tributaries due to greater use of the area for sport and subsistence fishing. Collectively, these cumulative effects from onshore oil and gas development and production could reduce the size and structure of fish populations, diminish individual fish condition, and shift local fish community composition and species distribution.

Offshore oil and gas development and production in the Chukchi and Beaufort seas could have additional impacts on fish that could accumulate. Onshore support infrastructure associated with offshore activities would increase the extent of the anthropogenic footprint already projected to occur with NPR-A development, adding to the effects described above. Causeways, docks, or other similar structures could further hinder or divert marine or anadromous fish migrations along the coast, with each coastline structure exacerbating the impact. This support infrastructure for offshore activities could also have a synergistic effect by increasing the amount or rate of onshore development, which could link into these facilities, roads, and pipelines. Similarly, infrastructure built for coastal onshore oil and gas activities could encourage offshore development, effectively creating a positive feedback loop.

A commercial gas pipeline from the North Slope to more southerly regions of Alaska or Canada would not necessarily affect fish in a direct manner that would contribute to cumulative effects on fish for the region. However, the construction of this pipeline would substantially increase the likelihood for gas resources to be developed within the NPR-A and on State land to the east. From this perspective, cumulative effects on fish in the region would likely be greater if the pipeline is built than if it is not built.

As discussed in the section “Oil and Gas Exploration and Development Activities” on page 77, effects on fish from North Slope oil spills on land thus far have not accumulated because the spills have been small and cleanup and rehabilitation efforts have generally been successful. Regardless, given the magnitude of development scenarios for the NPR-A and lands to the east, this situation could change, with the probability of spills entering aquatic habitats increasing. Also, as pipelines from onshore and offshore development age and degrade, spills would probably be more frequent and effects on fish could be additive. Furthermore, oil and gas development in the Chukchi and Beaufort seas would be much more likely to lead to spills that would enter coastal waters and impact anadromous and marine fish. Effects on fish from even small individual spills in coastal waters could accumulate over time.

To date, very little abandonment (except for single exploration or development wells) has occurred anywhere on the North Slope. However, abandonment of gravel pads and roads, as well as pipelines, would most likely only have a temporary impact on local aquatic habitats. Removal of problematic stream crossing structures would contribute to positive cumulative effects on fish by allowing fish to reach habitats that were previously made inaccessible. Since many abandoned North Slope gravel mines have provided additional overwintering and spawning habitat for fish, it is assumed that future efforts would produce similar results and lead to cumulative effects that are positive for fish. The use of explosives for delineation well or development platform abandonment in the Beaufort or Chukchi sea would likely injure and disturb fish in the immediate vicinity, but the impact would be momentary.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

The extent of expected cumulative effects on fish from oil and gas activities in the NPR-A and surrounding areas would vary depending upon the alternative selected under this IAP/EIS. Onshore permanent infrastructure (roads, pads, pipelines) and gravel mining are elements of development and production that are likely to contribute to cumulative effects on fish. The anticipated length of roads and pipelines in the

NPR-A is representative of the relative scale of projected development under each alternative; the more roads and pipelines, the more supporting infrastructure and associated activities. From this perspective, the most cumulative impacts on fish would be expected under Alternative D (3,940 miles of roads and pipelines). The estimated incidence of infrastructure impacts that could accumulate would be 42 percent less under Alternative A, 52 percent less under Alternative B-1, 48 percent less under Alternative B-2, and 3 percent less under Alternative C. Cumulative impacts attributable to gravel mining would also be expected to be greatest under Alternative D (no more than 55 gravel pits). The magnitude of those impacts would be an estimated 27 percent less for Alternative A, 47 percent less for Alternative B-1, 44 percent less for Alternative B-2, and 5 percent less for Alternative C. However, whether or not the net impact from gravel mining would be negative or positive for fish would depend on site-specific management decisions.

The potential for the most additive impacts to occur from causeways, or other similar structures that extend into coastal waters, would be under Alternative D which would permit development anywhere along the NPR-A coastline (1,200 miles). A similar degree of risk would occur under Alternative A, which would allow development along the entire coast except for Kasegaluk Lagoon. Comparatively, causeways could only be built along approximately 50 percent of the coastline under Alternative C and less than 10 percent of the coastline under Alternatives B-1 and B-2. Also, while Alternatives A, B-2, C, and D would enable offshore developments in the Chukchi and Beaufort seas to link with infrastructure in the NPR-A, Alternative B-1would prohibit a pipeline coming ashore from the Beaufort Sea. Access points to the NPR-A from Chukchi Sea developments would differ for the various alternatives. A pipeline or other oil and gas infrastructure could not go through the Kasegaluk Lagoon Special Area under Alternatives A, B-1, and C or through the Peard Bay Special Area under Alternatives B-1 and C. Otherwise, a pipeline that extended from that region to Umiat, Alpine, or other locations east of the NPR-A could be built under any of the alternatives and the potential impacts on fish would be the same.

Conclusion

Past and present cumulative effects on fish from anthropogenic activities on the North Slope are limited to the greater Prudhoe Bay area to the east of the NPR-A and along the NPR-A coastline. The scale and distribution of future cumulative effects on fish will largely depend on the extent and location of oil and gas development infrastructure in the region. In the past, non-oil and gas effects on fish accumulated within the immediate vicinity of Distant Early Warning-Line stations, which were built approximately 50 miles apart along the coastline. However, the effects were chiefly associated with construction and operation and have stabilized and moved towards recovery since abandonment occurred. In the future, these effects should diminish if no new facilities are constructed and clean-up efforts continue. Although seismic activities and exploration in the earlier years of work on the North Slope were detrimental to fish, those impacts were likely localized and acute and did not accumulate. Advances in techniques now used for seismic surveys (Vibroseis) and exploration (temporary ice infrastructure) have far fewer potential impacts on the environment and should help avoid future cumulative effects on fish.

Gravel infrastructure (roads, pads, airstrips) and gravel mining associated with North Slope oil and gas development and production have caused effects on fish that have accumulated by impeding fish movements and significantly altering the physical and chemical conditions of fish habitat. However, the positive effect of creating additional deep-water habitat during gravel mine abandonment is believed to offset some of the negative impacts that occurred during mine construction and operation. Causeways at Prudhoe Bay and the Sagavanirktok River delta have caused cumulative effects by impacting fish movements, local fish community structure, and water quality. While retrofitted breaches partially reduced these impacts, they still persist today. Future causeways will lead to additional cumulative effects on fish unless improved alternatives can be utilized. Oil and gas development and production in the Chukchi Sea, Beaufort Sea, or to the east of the NPR-A would require additional facilities and infrastructure that would cause impacts on fish that would be additive to impacts from NPR-A development. Other construction projects, such as a road connecting Umiat with the Dalton Highway or commercial gas pipelines from the North Slope to southern regions, would increase the likelihood of development impacts on North Slope fish.

If predicted shifts in physiochemical characteristics of the environment occur with climate change, this could contribute to an increased level of cumulative impacts on fish in the Arctic. For example, if water temperatures increase excessively, metabolic stress for many fish species would be greater and result in lower tolerance thresholds to land-use impacts. Changes in hydrologic regimes could include timing and quantity of flow and could contribute to fish passage problems at stream channel or wetland road crossings. Potential effects from climate change could be positive for fish, as well. If the ice-free period for freshwater and marine habitats increases significantly, this would mean a longer feeding season for fish and shorter periods of stress during winter. A moderate increase in water temperature could also contribute to a more productive feeding season and further enable fish to survive the winter and additional stress from oil and gas activities.

4.8.7.8 Birds

This section discusses the potential cumulative effects to non-special status bird species that could result from management actions in the NPR-A; a discussion of effects to threatened and sensitive bird species is given in section 4.8.7.11, “Special Status Species.” The geographic extent of this analysis includes the North Slope and the full extent of the migratory and wintering range of the species discussed. Approximately 80 species of birds commonly or regularly occur in the planning area. Reasonably foreseeable impacts are considered from the present until 2100. Most of these species, including loons, waterfowl, shorebirds, raptors, passerines, and seabirds are migratory and occur in the NPR-A only during the summer breeding season. The majority of the activities that could potentially contribute to the cumulative effects to birds in the NPR-A would result from oil and gas exploration and development that may occur in addition to the proposed action of this plan. In addition, any analysis of cumulative effects to birds must include effects to birds during migration and at wintering areas, where impacts to birds could be independent of activities in the NPR-A. Because bird populations can show substantial changes among years, it is often difficult to determine if effects are accumulating at the population level, or merely reflect short-term shifts in population numbers.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Activities that occur on the North Slope and are not directly related to oil and gas development and contribute to the cumulative effects to birds in the NPR-A include subsistence activities (including hunting, fishing, berry picking etc.), recreational use, activities associated with scientific surveys and research camps, village expansion, cleanup of old oil and gas exploration sites, and activities associated with government actions (e.g., cleanup of abandoned well sites). These activities could affect tundra nesting birds by causing: (1) temporary or permanent habitat loss; (2) various types of disturbance related to equipment and facility noise, vehicular and air traffic, and pedestrian activities; (3) increased predation; and (4) mortality resulting from collisions with vehicles or structures, or exposure to contaminants, including spills of hazardous materials. Activities that would likely cause the greatest effects to birds or bird habitat are those that lead to habitat loss and associated increases in human caused disturbances.

Distant Early Warning-Line sites and other military facilities, villages, public roads, airstrips, landfills, and other non-oil and gas infrastructure have caused the loss of habitat for some bird species and increased levels of disturbance within the NPR-A and within the six North Slope villages considered in this cumulative effects analysis. Impacts from military Distant Early Warning-Line stations include habitat loss for some species resulting from areas where gravel and sand have been removed along the coast and placed on tundra in order to develop roads, airfields and support buildings. Habitat loss due to the placement of gravel on the tundra persists today and these sites also provide a potential starting point for recreational and sport hunting trips. It is very likely that the sand and gravel removed from the coast has been replaced via long-shore transport and/or river flow and that habitat has been restored to its original condition. Hazardous material or debris and structure removal has occurred at many of the Distant Early Warning-Line stations resulting in a reduction in contamination of areas potentially used by birds. Clean-up activities at these and other sites in the NPR-A involves the use of fixed-wing aircraft or helicopters, to access remote areas, which can disturb birds.

Since the early 1900s, six villages have been established or reestablished in the western North Slope and these villages have continued to grow in area and in population resulting in habitat loss and increased human disturbance to birds. The footprint of the existing communities considered in the cumulative effects analysis of this document are expected to double in size by 2050 (see section 4.8.2) if onshore and offshore oil and gas development increases as predicted by Thomas et al. (2009). This increase will likely lead to an increase in the filling of wetlands and loss of natural habitats, increase in size of landfills and an increase in human activities that may cause disturbance to birds of many different species. Areas around these villages are known to host many different species of birds and the effects to birds would depend on into which habitats the expansion actually occurs. Impacts from activities associated with military uses and village expansion would likely be localized, would be expected to persist, may accumulate and would likely have a greater negative effect if habitat loss and/or human disturbance occur in an area of high bird density such as near lakes containing large numbers of molting geese.

Private and commercial air traffic occurring on the North Slope likely impacts birds very little as that type of traffic is usually at elevations above that which most often causes disturbance. An exception would be air traffic that flies close to cliffs where raptors are nesting as aircraft may startle incubating birds and potentially cause egg loss. Aerial surveys for wildlife in the planning area could include both fixed-wing aircraft and helicopter surveys. Low-level fixed-wing aerial surveys would probably have little effect on birds due to the short amount of time during which aircraft would be in a particular area. Wildlife telemetry studies involving the use of helicopters could cause greater disturbance to birds due to the take-offs and landings required for deploying ground personnel for attachment of transmitters. The effects to birds from these activities could range from temporary displacement from preferred feeding habitats to nest abandonment and loss of production for the breeding season. Impacts would likely be localized and the effects would not be expected to persist or accumulate.

Various types of disturbances affect tundra-nesting birds near seasonal camps. Noise and ground activities disturb feeding, nesting, molting and brood-rearing birds, causing temporary or permanent displacement from feeding or nesting areas potentially affecting energy budgets and productivity. Aircraft activity to mobilize and re-supply summer camps could disturb birds along continually used flight corridors and near airstrips during take-offs and landings. Birds could also suffer mortality due to collisions with aircraft. Nesting birds near seasonal camps could suffer mortality or egg loss due to predators attracted to anthropogenic sources of food at camps. Effects of this type of visual and noise disturbance could range from temporary displacement from preferred habitats to nest abandonment to death. Impacts would likely be localized and the effects would not be expected to persist or accumulate. Summer boat traffic could occur on rivers on the North Slope for purposes such as recreation, sport hunting, subsistence activities, and to resupply camps. Numerous studies have reported on the effects of boat disturbance to nesting raptors. However, current levels of boat activities on these rivers have apparently not impacted raptors negatively, as some populations; particularly the peregrine falcon population in the Colville River Special Area has been increasing in recent years (Ritchie et al. 2003).

Oil and Gas Exploration Activities

The primary factor associated with oil and gas exploration activities that affect birds in the NPR-A is loss of habitat. Most seismic surveys and exploration drilling activities occur during the winter months when most birds are absent from the North Slope; consequently direct effects from disturbance is not a factor for the majority of the birds using the planning area. A few species, including snowy owl, gyrfalcon, ptarmigan, and common raven, may be present in the planning area during winter, and may be temporarily displaced from preferred feeding areas by oil and gas exploration activities. Given that these activities occur within only a small portion of the North Slope at any time, any effects are unlikely to accumulate or persist. Land based seismic surveys have been conducted over most of the North Slope since 1940 and vegetation has been disturbed to varying degrees depending on a variety of factors related to the type of equipment used and the winter travel restrictions that have been in place. Refer to section 4.8.7.5 for information on cumulative effects on vegetation from seismic surveys. Use of newer technologies, including vehicles that apply less pressure to the ground and restricting travel to periods when there is adequate snow and frost cover to protect vegetation, has reduced the level of impacts to vegetation.

Seismic activities may have indirectly affected birds during the summer breeding season via habitat disturbance as ice-roads, snow trails and ice-pads temporarily alter tundra habitats by compressing standing-dead vegetation or delaying the growth and development of vegetation, due to protracted ice melt. These impacts to vegetation, thus bird habitat, could conceivably persist for more than a few years and, therefore accumulate. Effects to birds from the previous use of airguns for boat-based seismic work in Teshekpuk Lake were not documented, however it is reasonable to assume that if loons and waterfowl were present in the area of the seismic work then they may have been displaced from preferred feeding habitats by either the boat traffic or the seismic noise while surveys were being conducted. However, these surveys have only occurred a few times in the past, and it is unlikely that effects to birds have persisted or accumulated. Other sources of habitat loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Based on a report by the National Research Council (2003), in 2001 approximately 1,700 acres had been impacted by these types of sites on the North Slope in the past, and 1,130 acres of disturbed areas were still evident. Most of these sites were developed before 1977, thus, their effects on the vegetative landscape have persisted for decades, and are likely to persist for several more decades. As industry has shifted towards use of ice roads and ice pads during exploration (expected effects would be the same as from modern seismic exploration), loss of bird habitat has slowed greatly and is expected to have minor effects that could impact bird habitat for several years, but would be unlikely to accumulate because their effects are short-term and of limited geographic scope.

The oil and gas industry in Alaska conducts marine seismic surveys in the summer and fall, and on-ice seismic surveys (in the winter) to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or sub-sea terrain. Marine seismic surveys would involve both 2D and 3D survey methods. Because approximately 92,000 line-miles of 2-dimensional seismic data were collected in the Beaufort Sea between 1965 and 1997, future seismic surveys would be mostly 3-dimensional surveys. In the Chukchi Sea approximately 80,000 line-miles of 2D seismic data were between 1970 and 1990, and subsequent seismic surveys (post-2006) are likely to be 3D surveys (USDOI Minerals Management Service 2009). Seismic surveys during exploration activities in the Minerals Management Service Beaufort Sea and Chukchi Sea Planning Areas are anticipated to result in a negligible effect on birds in the action area (USDOI Minerals Management Service 2009). Impacts would have potential to have greater negative effect and potentially increased accumulated effect if the disturbing or displacing activity occurs in high density molting areas.

Water used in the construction of ice roads and pads used for exploration activities is withdrawn from deep lakes in areas adjacent to the ice road and pad locations. It was feared that winter water withdrawal would alter lake levels and affect adjacent bird habitats, but investigations into this practice have documented lake recharge in the spring (Baker 2002; Hinzman et al. 2006). Since use of lakes in the past has varied, and few lakes would have had water withdrawn over multiple years, it seems unlikely that the effects of past use of lakes for water withdrawals would accumulate and negatively affect bird habitat.

Oil and Gas Development and Production

Loss and alteration of habitat, disturbance, and reduction in nesting success associated with predation are the mechanisms by which the greatest effects to birds have occurred on the developed portions of the North Slope in the past and persist today. To the extent that birds populations use habitat both in NPR-A and in these areas to the east of the Reserve or that birds displaced by these past activities currently use habitat in the planning area, impacts from this past oil and gas activity are part of the cumulative impacts for NPR-A's birds. Peat and gravel roads, gravel pads and airstrips, and gravel mines have caused the direct loss of bird habitat. For the North Slope as a whole, it is estimated that by 2001 gravel had been used to construct about 8,998 acres of roads and pads in the oil fields, 332 acres of the North Slope portion of the Dalton Highway, 1,765 acres had been impacted by other oil field related disturbances, and gravel mines had impacted another 6,364 acres for a total loss of 17,459 acres of habitat loss to industrial development (Table 4-41). These numbers represent permanent loss of bird habitat unless the areas are rehabilitated in such a way as to return them to their original condition. Approximately 4,500 acres of gravel mines had been rehabilitated but only 70 acres of gravel pads (National Research Council 2003). However, rehabilitation of gravel mines does not produce nesting habitat for birds, and rehabilitation of gravel pads has produced mixed results that have not restored areas to original conditions although gravel pads has resulted in the creation of habitat for those species that nest on gravel. Effects to birds from loss of habitat will accumulate as additional habitat is lost to gravel coverage, however newer developments are only expected to require one-tenth of the amount of gravel fill that was required for early oil fields (National Research Council 2003).

Due to the limited amount of data on bird populations, low densities of breeding birds and the large size of the area covered by oil field structures the magnitude of effects to birds from the past and present habitat loss on the North Slope is a matter of debate. The National Research Council (2003) concluded that the placement of oil field facilities does not appear to have reduced the overall densities of birds in those areas. There is higher probability that some negative effects of habitat loss have been incurred by those species that use habitat types that are limited in occurrence, as there would be fewer alternative locations for those birds to relocate to. Whatever effects have occurred would persist as long as gravel remains in place.

In addition to the direct loss of habitat, construction of gravel structures has altered the moisture regime of the nearby tundra by changing natural drainage patterns and areas where snow accumulates. These changes have altered the species composition and occurrence of the plant community near gravel structures and may adversely affect birds. Additional impacts include dust deposition and the formation of impoundments. The passage of vehicle traffic over gravel pads and roads results in dust and gravel being sprayed over vegetation within about 30 feet of the pad or road, and a noticeable dust shadow out to 150 feet or more. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003). However, impoundments created by road and pad construction and dust deposition have created new feeding and brood-rearing habitat that has been beneficial to some bird species. Noel et al. (1996) reported that the areas occupied by impoundments in the Prudhoe Bay area generally supported higher waterfowl densities than the same areas did prior to development. Kertell (*in* Truett and Johnson 2000) reported no significant differences in nutrient availability or in phytoplankton biomass, and in only two cases were there differences in production of invertebrate taxa potentially important as food sources for loons and numbers of Pacific loons when comparing use of natural ponds and impoundments in the Prudhoe Bay area. The ratio of spatial extent of indirect effects (roadside flooding, dust, debris, thermokarst) to spatial extent of direct effects (gravel fill) average 6:1 (National Research Council 2003). Using this ratio across North Slope oil facilities and the Dalton Highway suggests that about 56,000 acres have been indirectly affected by gravel fill (8,998 acres gravel footprint plus 332 acres, times six; Table 4-41). These impacts, both beneficial and adverse, persist today and are expected to persist as gravel fill remains and vehicle travel occurs on the pads and roads.

Numerous types of disturbances could result from the construction and operation of oil and gas development and production facilities, including those caused by aircraft, vehicular, pedestrian, and vessel traffic. Some level of disturbance to birds from these activities would be unavoidable. Impacts would be most prevalent where facilities were located in habitats with high bird concentrations or near those species that are particularly sensitive to disturbance.

Disturbance to waterfowl from aircraft is well documented (e.g., Schweinsburg 1974, Ward and Stehn 1989, Derksen et al. 1992, McKechnie and Gladwin 1993, Ward et al. 1999). Responses of birds to aircraft included alert postures, interruption of foraging behavior, and flight. Aircraft disturbances could displace birds from feeding habitats and negatively impact energy budgets. However, an avian monitoring study at the Alpine field showed that successful white-fronted goose nests were generally closer to the Alpine field airstrip, the flight path, and the nearest gravel source than unsuccessful nests, although most comparisons were not substantially different. Johnson et al. (2003b) also reported on tundra swans and yellow-billed loons nesting in proximity to the Alpine field airstrip. When compared to pre-construction numbers, waterfowl nests near the Alpine airstrip declined in the area within 3,250 feet of the airstrip after construction began (Johnson et al. 2003b). Although the potential exists for displacement of some nesting birds near routinely used aircraft landing sites as a result of numerous overflights, landings, and takeoffs, some birds may habituate to routine air traffic, while others (e.g.; brant) fail to do so. The cumulative impact to birds from repeated aircraft disturbance is currently unknown.

Vehicular and pedestrian traffic and oil field construction activities are known to disturb birds. Johnson et al. (2001) studied the effects of disturbance resulting from the construction and operation of the Alpine oil field facility on a suite of bird species and found that the distribution and density of white-fronted goose nests declined in two of the three heavy-construction years and was negatively correlated with overall noise levels and frequency of aircraft, traffic, and pedestrians Johnson et al. (2001) also determined that the number of tundra swan nests in the Alpine varied little over the six years of their study and that reactions to pedestrians were very highly variable and varied among individual swans.

The National Research Council (2003) found that the inadequate disposal of garbage has resulted in artificially high densities of gulls, ravens, and mammalian predators in the oil fields. There is evidence that nesting success for several species of ground-nesting birds may be lower in oil fields than in undeveloped areas (Troy 1996; Anderson et al. 2000, Liebezeit et al. 2009). Sedinger and Stickney (2000) attributed low brant nest success in oil fields to high predator populations and Johnson (2000) noted a similar relationship for snow geese in some years. Increases in the number of predators in areas of development could have an additive impact particularly for species with low or declining populations. In recent years, North Slope oil field developers have installed predator-proof dumpsters to minimize attraction of predators. This policy has mostly been successful at the Alpine field, where Johnson et al. (2003b) reported no increase in the numbers of predator species, other than the common raven, after development. Although unmeasured predation of bird nests likely has had a negative cumulative effect on some of the bird populations in the developed areas of the North Slope and this effect is likely to have accumulated.

Bird mortality has resulted from collisions with buildings, power lines, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore and offshore oil and gas development. Offshore activities are most likely to impact birds during the late summer/fall staging period, when relatively large numbers of loons, long-tailed ducks, eiders, and other waterfowl are staging, migrating and molting in marine areas. Migration pathways may include areas where coastal and offshore production facilities are constructed, so collisions with these structures and with vessel and helicopter traffic used for transport of personnel and equipment, conducting oil spill response exercises or responding to an oil spill, could occur. Bird collisions are unlikely to represent a significant source of bird mortality at the population level. However, individual bird losses due to collisions in developed areas accumulate with increases in development and add incrementally to other impacts. If rare species are represented among the colliders, this could be an important effect for that species.

The largest spill in the North Slope oilfields (over 200,000 gallons) occurred in March of 2006, but this resulted in essentially no direct impacts to birds due to the timing of the spill, which allowed cleanup to take place before the spring melt. Indirect impacts to bird habitat are likely to have occurred as a result of the spilled oil and the subsequent clean-up effort. No notable spills into the marine environment have occurred. Small spills have occurred but cleanup and rehabilitation efforts have been successful and relatively few birds have been impacted (National Research Council 2003) and ecosystems have generally recovered (Jorgenson 1997). The cumulative effects of oil spills on the North Slope have added only incrementally to impacts on birds.

Offshore oil development and production, which occurs in both state and federal offshore marine waters of the North Slope, began in the early 1980s. Offshore activities rely on helicopter and marine vessels to transport equipment and personnel. Much of this activity takes place in the winter when most birds are not present, with the exceptions being those species that winter in recurrent gaps in the sea ice (e.g., Ross and ivory gulls, thick-billed murre, black guillemot) within the offshore marine waters of the North Slope.

Helicopter activity, barge and crew vessel traffic, and spill response training activities do occur during the summer. During the summer open-water seasons of 2001 and 2002 at the Northstar development off Prudhoe Bay, helicopter activity ranged from 477 to 989 round trips, crew vessel activity ranged from 469 to 824 round trips, and barge traffic ranged from 63 to 64 round trips (Williams 2002, Williams and Rodrigues 2003). Vessel traffic not related to oil development also occurs and could increase due to the recent extended open water periods in marine waters off the coast of the North Slope. These activities have likely displaced birds using the marine environment in the past, but the magnitude of the effect and the extent of accumulation is unknown.

Factors Outside of the North Slope

Wintering grounds and portions of migratory routes of many bird species lie in areas outside of the North Slope, including areas within the U.S. and several other countries and regulated or non-regulated development in these areas can negatively impact or destroy critical bird habitats. Various types of contaminants and toxins from industrial and agricultural activities can enter either terrestrial or marine environments and affect bird mortality or reproductive success. Oil spills have been an obvious source of bird mortality at numerous locations around the world. Commercial fishing activities have caused changes in predator-prey relationships that could affect wintering loons and waterfowl that feed in offshore marine habitats. Marine birds could also become entangled in fishing gear currently being used in commercial fishing activities or in abandoned gear that persists in marine environments. Many waterfowl species are hunted for sport during the fall migration and on the wintering grounds. Subsistence users take waterfowl or other bird species during spring and fall hunts, as well as eggs of some species during the nesting season. There is evidence that contamination of feeding habitat with spent lead shot may result in lead poisoning of waterfowl in some areas. All of these factors add to the cumulative loss of individual birds, and in some instances, can have population-level effects.

Summary of Past and Present Impacts and Their Accumulation

Approximately 2,500 acres of habitat have been directly impacted by non-oil and gas development on the North Slope and those impacts continue to persist. Oil and gas activities have caused an additional habitat loss or alteration of over 17,000 acres that persist today. Whether these impacts are associated with non-oil and gas residential and commercial development, or oil and gas activities, the impacts to bird habitat are additive to future impacts and would likely persist for several decades or more in the absence of an active reclamation program. The typical gravel pad and amount of roadway needed to service a development have become smaller over time, reducing the incremental amount of bird habitat lost due to new development as compared to past levels. Direct and indirect effects from disturbance, of many different types, are difficult to measure, but are likely accumulating as the number of developments and the amount of developed area increase. New oil and gas developments have reduced their footprint size and the corresponding direct effects have been reduced, however these new developments often rely on aircraft support for transportation of personnel and equipment potentially increasing disturbance to feeding, nesting, staging and molting birds. The impacts of predators on bird populations may be waning as industry reduces the amount of predator-attracting garbage in the fields. Habitat loss and disturbance can add incrementally to the impacts of development on birds. Whether past impacts to bird populations from habitat loss or disturbance are associated with non-oil and gas residential and commercial development, or oil and gas activities, these impacts are additive to any potential future impacts.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities as described above would continue to result in the loss of small amounts of bird habitat and cause disturbance to birds. In many cases, loss of habitat from these activities would be temporary, lasting only a season or a few years. Habitat loss and disturbance associated with military facilities, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future. Villages are likely to increase in size, causing the loss of additional habitat, increased disturbance and will likely increase the predation rate of birds and nests in the vicinity of the human expansion. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 and then level off for the remainder of the 21st century. An increase in marine vessel traffic is expected due to the recently extended open water period in the Chukchi and Beaufort seas.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Based on projections developed for the NPR-A and extrapolated to the rest of the North Slope, on-shore seismic exploration activity could take place on up to 86,400 acres annually. Exploration sites with ice pads, disturbed areas around these pads, ice airstrips, and ice roads would also be expected to be developed and are sources of habitat loss. Impacts from ice roads and pads are short-term (Yokel et al. 2007) and are not expected to accumulate. However, if climate warming shortens the winter season to the point where ice roads are not economically feasible for exploration drilling, the alternatives may cause greater habitat impacts than current practices. In this case, exploration and climate change would have synergistic effects on habitat loss from exploration activities.

Seismic activity has occurred for many years in the Chukchi and Beaufort seas and is expected to continue in the future during the open water season (June through October). Offshore and near shore seismic work includes the use of ice breakers, seismic vessels, support vessels and helicopters. Offshore seismic surveys are conducted using an airgun and receiving cable arrays. There is potential for birds to be impacted by offshore seismic surveys due to disturbance and potential displacement of birds from preferred feeding, molting and staging areas if bird use areas overlap with seismic activities. However, acoustic noise from airgun arrays and exploration-related vessel traffic would be predominantly transient and would not typically occur in the same location with much frequency. Impacts would potentially have greater negative effect and increased accumulated effect if the activity occurs in an area of high bird density or during a period when birds are flightless and less able to leave the area.

In the Chukchi Sea exploratory drilling operations are likely to employ drillships with ice-breaker support vessels during the summer exploratory drilling season. Drilling operations are expected to range between 30 and 90 days at each well site. Considering the relatively short open-water season in the Chukchi (June through October), the

Minerals Management Service estimated in their 2007 Lease Sale 193 EIS that up to four wells could be started by one rig each drilling season. However, it is more likely that only one to two wells could be drilled, tested, and abandoned during a single season. During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters would probably fly from Barrow or Wainwright at a frequency of 1-3 flights per day. Support vessel traffic would be 1-3 trips per week, also out of Barrow or Wainwright.

Of particular concern is the potential effect of disturbance from offshore seismic activities to the designated critical habitat for spectacled eiders in Ledyard Bay (U.S. Fish and Wildlife Service 2001). Currently regulations prohibit any Outer Continental Shelf-related activity in the Ledyard Bay Critical Habitat Unit, including seismic surveying, exploration drilling, or support vessel traffic, additionally there are currently no Outer Continental Shelf Leases within this critical habitat unit. Most waterfowl are particularly sensitive to disturbance during staging or molt periods (Ward 1994, Ward et al. 1999). The Ledyard Bay area has been used by as many as 33,200 spectacled eiders and the molting population is believed to include the entire population of successful females and young from the Arctic Coastal Plain (Petersen et al.1999). Overflights or vessel traffic through this area when eiders are present could result in disturbance effects to a large number of eiders which would be additive to other effects.

Exploration wells in the federal waters are likely to be vertical wells and in shallow OCS waters, exploration wells are likely to be drilled from man-made gravel or ice islands. In waters (greater than 15 meters) mobile, bottom-founded drilling structures could be used. Drillships with icebreaker support vessels are typically used in water depths greater than 25 meters. Artificial gravel or ice islands may be employed as drilling platforms in less than 15 m of water, and their construction and supply would be supported by ice-roads across the landfast ice zone. In deeper water, bottom-founded structures and drillships would require supply vessels and helicopter support. Due to the sparse distribution and typical small flock size of special status species in the offshore waters of the Beaufort Sea offshore exploratory activities would not be expected to impact large numbers of individuals. Overall, effects on birds from seismic activities and exploration in the NPR-A, lands to the east, and in the Chukchi and Beaufort seas would be additive and would likely accumulate. Development of a road between Umiat and the Dalton Highway could increase exploration operations along the road and also within the NPR-A due to improved accessibility to lands. The road may also provide increased access to game birds by sport and subsistence hunters, and if hunting were not appropriately managed this could result in cumulative mortality to some species.

Oil and Gas Development and Production. Development activities that could contribute to cumulative effects to bird habitat on the North Slope include oil and gas development, including the NPR-A; federal and State offshore oil and gas development (including the construction of onshore infrastructure); state and Native corporation onshore oil and gas development, both conventional and unconventional; oil and gas transportation, including commercial gas pipelines; and road construction. All of these activities involve construction of infrastructure that would destroy bird habitat within the immediate footprint of the project and indirectly affect birds and their habitats through disturbance, dust, flooding, changes in natural drainage patterns, thermokarst, snow drifting, and oil and chemical spills.

The increase in the amount of area disturbed by oil and gas development on the North Slope has slowed in recent years. Before 1988, the oil field road network grew by about 24 miles per year but slowed to only 3 miles per year since 1988. The average rate of all gravel placement was about 421 acres per year before 1988, and only 42 acres per year between 1988 and 2001 (National Research Council 2003; Table 4-38 on page 22). If the current rates continue into the future for areas outside the NPR-A, the ratio of gravel footprint acres to gravel mine acres remains about 5:1 (see section 4.2.1.2. “Discovery and Development”, Volume 2), and assuming Alternative D is implemented within the NPR-A, about 21,800 additional acres would be covered by gravel, and 4,350 acres impacted by gravel mines, between 2012 and 2100. Approximately 16,700 acres would be indirectly affected by dust, changes in hydrology, and thermokarst. Specific sources of direct and indirect bird habitat loss through future development are detailed below.

Road and Pipeline between Umiat Area and Dalton Highway. This analysis assumes that a road and pipeline(s) up to 102 miles long would be built between Umiat and the Dalton Highway. The footprint of the road, ancillary facilities, and material sites would be almost entirely outside of the NPR-A and is estimated to cover 1,000 acres (Table 4-40 on page 45). An oil pipeline along the same route would likely be above ground, whereas a gas pipeline would be buried and would affect about 185 acres of bird habitat in the long-term. Activities to maintain the road and pipeline would create disturbance impacts to birds that would likely be similar to or greater than those from current oil field development depending on the types and amount of traffic allowed on the road. A road and pipelines leading from the Dalton Highway to the boundary of the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in the amount of bird habitat lost in the NPR-A through both direct and indirect actions. The road would also provide increased access to sport and subsistence bird hunters, and if hunting were not appropriately managed this could result in cumulative mortality of some bird species.

Chukchi Sea Development. If development occurred in the Chukchi Sea some potential bird habitat may be altered or eliminated at the site of onshore facilities (administrative, maintenance and housing infrastructure and transportation facilities including a marine dock and airstrip along with roads connecting facilities) and pipelines. Onshore support infrastructure for Chukchi Sea development would likely be sited near and make use of existing infrastructure. While any habitat loss would be long-term, the areas disturbed would represent a very small portion of the bird habitat present on the North Slope. Chukchi Sea development in federal waters could include up to 54 exploration and delineation wells, 880 platform production wells, and 235 subsea production wells, and construction of up to 1,000 miles of offshore pipelines and up to 500 miles of onshore pipelines (see section 4.8.3.2). Disturbance to birds by these facilities would likely be dependent on their location as some areas of the coast are very important for large numbers of brood-rearing, molting and staging birds and facilities located close to these important areas could cause disturbance that could negatively affect species on a population level. Careful siting of any new facilities to avoid important bird habitats would reduce the magnitude of any potential effects on local bird populations. Any construction activities that take place in summer (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mile) of the construction site (Bureau of Ocean Energy Management 2011). Localized burial of potential prey and destruction of foraging habitat as a result of pipeline trenching or island construction (if utilized in State-owned waters) are not expected to cause a significant decline in prey availability. It is likely that most construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when most birds are absent. Winter construction would utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats and the potential effects to tundra habitats would be the same as those outlined in previous sections. Potential impacts on birds using marine and coastal areas from activities in the Chukchi Sea include behavioral disturbance due to the presence of, and noise generated by, equipment, vessels, aircraft and human activity. Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb marine species feeding in limited areas of open water and waterfowl in coastal waters, causing birds to leave the area.

Similarly, overflights in summer could displace waterfowl and loons from preferred foraging areas and from coastal nesting or brood-rearing areas such as the lagoon systems of the Chukchi Sea. The type of response elicited by the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (Minerals Management Service 2002b). Marine vessel trips could disturb loons and waterfowl in preferred foraging, molting, and staging areas, potentially causing them to leave the area and move to potentially less favorable habitats. However, the amount of vessel and aircraft traffic that could occur would be relatively limited. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel traffic. If a pipeline is built east across the NPR-A and on to Trans-Alaska Pipeline System, it would add little long-term impacts to bird habitat. A small amount of bird habitat would be permanently lost within the footprint of the new pipelines. If a road were to be built along the pipeline route, the total impact may add up to 3,000 acres, resulting in more substantial loss of bird habitat (see Table 4-40). A pipeline and road across the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in acres of bird habitat lost in the NPR-A.

Beaufort Sea Development. Offshore development in the Beaufort Sea may require onshore processing facilities and certainly would require onshore pipelines. Offshore production platform would be accessed by helicopter, barge, and in nearshore areas, by winter ice roads. A subsea pipeline would bring the petroleum into an onshore pipeline gathering system, where it would be processed, either in existing facilities or, if too distant from existing facilities, new processing facilities. The Beaufort Sea development program would permanently eliminate potential bird habitat at the sites of offshore platforms and pipelines and construction of onshore gathering and processing facility and pipelines. While this habitat loss would be long-term, the areas disturbed would represent a small portion of the habitat present on the North Slope. Offshore development in federal waters could include the placement of up to 40 exploration and delineation wells, 310 platform production wells, and 25 subsea production wells, and the construction of up to 423 miles of offshore pipelines and 290 miles of onshore pipelines. Disturbance to birds by these facilities would likely be dependent on their location as some areas of the coast are very important for large numbers of brood-rearing, molting and staging birds and facilities located close to these important areas could cause disturbance that would negatively affect species on a population level. Careful siting of any new facilities to avoid important bird habitats would reduce the magnitude of any potential effects on local bird populations. Any construction activities that take place in summer (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mi) of the construction site (Bureau of Ocean Energy Management 2011). Localized burial of potential prey and destruction of foraging habitat as a result of pipeline trenching or island construction are not expected to cause a significant decline in prey availability. It is likely that most construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when most birds are absent. Winter construction would utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats and the potential effects to tundra habitats would be the same as those outlined above.

Potential impacts on marine and coastal birds from activities in the Beaufort Sea include behavioral disturbance and collisions due to the presence of, and noise generated by, equipment, vessels, aircraft and human activity. Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989; Ward et al. 1994; Miller 1994; Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb marine species feeding in open waters and waterfowl in coastal waters, causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and loons from preferred foraging areas and from coastal nesting or brood-rearing areas such as the lagoon systems of the Beaufort Sea. The type of response elicited by the birds and the potential effect on the birds will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (Minerals Management Service 2002b). Marine vessel trips could disturb loons and waterfowl in preferred foraging, molting, and staging areas, potentially causing them to leave the area and move to potentially less favorable habitats. However, the amount of vessel and aircraft traffic that could occur under the proposed action would be relatively limited. Which birds could be affected, the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to vessel traffic. Collisions between birds and offshore and coastal structures are known to occur, especially during inclement weather and may involve many individuals of some species. Lighting can be designed to mitigate this collision potential.

Alternative B-2 of this plan would preclude leasing along the entire length of the NPR-A coast from Barrow to the lands owned by Nuiqsut's village corporation just west of the Colville River. However, Alternative B-2 does allow for new non-subsistence infrastructure to be developed on the coast between Barrow and the east side of Smith Bay and along Kogru Inlet which would allow for offshore development in the Beaufort

Sea to come onshore in this area. Thus a distribution system could be developed to tie the offshore development into the Trans-Alaska Pipeline System which may make smaller oil and gas fields in the northeastern NPR-A more economical. This may provide a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's scenarios and may lead to greater impacts to birds and their habitats.

Commercial Gas Pipelines. It is estimated that impacts to bird habitat on the North Slope from the Alaska Pipeline Project (a commercial gas pipeline) would total 4,500 acres during construction and half that figure during operations. It is expected that impacts to birds from this activity would be the same as those incurred by road and pad development within the NPR-A. This figure arrived at by assuming impacts to the 200-foot right-of-way during construction and to the 100-foot permanent pipeline right-of-way. Construction camps, pipe storage areas, and contractor yards will, to the extent possible, be located at previously disturbed sites. The project would include a gas treatment plant at Prudhoe Bay. Gravel pads and roads for the treatment plant would directly impact 200 acres of land; 155 acres would be for the gas treatment plant site and the remainder for access roads. In addition a 25-acre pad near West Dock would be constructed for a module staging area. Gravel will be obtained from existing borrow sites. Once buried, the pipeline would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor and would not accumulate. Estimates of the gravel footprint and borrow site footprint combined from the Alaska Gasline Development Corporations project would total 110 acres. All of this would likely occur far to the east of the NPR-A and would only be relevant to the cumulative impacts to NPR-A's birds to the extent that they also use habitat near any gas pipeline.

Another potential impact to birds may come from the proposed dredging of a channel in the Beaufort Sea in order to transport gas treatment plant modules to the Prudhoe Bay area using sealifts. The dredging would likely occur in the summer when large numbers of birds are using the nearshore waters for feeding, staging, brood-rearing and molting. If a dredging operation occurred in locations where large groups of birds were gathered they would likely be disturbed and move from the area. While the survival and fitness of individuals may be affected, significant population losses but would not be expected. Much greater impacts to birds and bird habitat from this pipeline would be the area affected by the gas development infrastructure and associated impacts that a commercial gas pipeline may make possible within the NPR-A and to the east.

Conventional Oil and Gas Development between the Colville and Canning Rivers. The increase in the amount of area disturbed by oil and gas development on the North Slope has slowed in recent years. If the current rates continue into the future for areas east of the NPR-A and the ratio of gravel mine acres to gravel footprint acres remains about 1:5, about 3,750 additional acres of bird habitat would be lost through the construction of pads, roads and airstrips through the year 2100 and 750 acres by gravel mines. About 27,000 acres (6:1 ratio) would also be indirectly affected by dust, changes in hydrology, and thermokarst. The effects of this continued development would be expected to have the same small incremental effect on birds and bird habitat as is currently occurring.

Unconventional Oil and Gas Development East of NPR-A. There are many challenges to this type of development on the North Slope, but for this cumulative analysis it is assumed that unconventional oil and gas development will become viable on better drained lands south of Prudhoe Bay and near the Dalton Highway. It is further assumed that this development will result in the loss of about 3,600 acres of bird habitat over the next 15 years. Better drained lands on the North Slope provide uncommon habitats that are used by a specific suite of bird species; therefore any loss of these uncommon habitat types may result in greater effect to those bird species than would be assumed by just the acreage loss to use. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on time and place of the impacts and the type of technology used.

Oil Spills and Gas Releases. Birds could be negatively affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. In general, loons, waterfowl, seabirds, and shorebirds are not expected to survive moderate to heavy oil contact. Oiled feathers lose their insulative and water repellent characteristics, and birds die of hypothermia (Albers and Gay 1982). Swallowed oil is toxic and causes impaired physiological function and production of fewer young. Oiled eggs have significantly reduced hatching success (Albers 1980). Vulnerability of bird populations to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of spill contact also is variable. It also depends on location, oceanography, weather patterns, and habitats typically occupied by and habits of the particular species. Because they are unable to fly, molting birds probably are the most vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., nesting, molting, brood-rearing).

A large onshore oil spill during the summer season could affect all species of birds. In the immediate vicinity of the spill, habitat contacted by oil would become unsuitable for bird use, and oil entering aquatic habitats could spread widely, potentially entering river deltas and nearshore marine habitats. Direct mortality could occur from loss of insulating capabilities of feathers should birds come in contact with oil, or from ingestion of contaminated prey. Oil that came in contact with eggs, either directly or through contact with partially oiled feathers of incubating adults, could negatively impact embryonic development.

Cumulative effects would depend on the number, size, location, and timing of spills, the type and effectiveness of the oil spill response, and the species and population size of birds exposed to the spill. If losses are substantial in a species with a low reproductive rate recovery may take many years, or populations may not recover to their pre-spill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate. Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution. Species dependent on widely dispersed prey would have more limited effects. Individual birds actively feeding young and dependent upon nearby food resources would be limited in their ability to seek uncontaminated prey elsewhere. If a leak from an onshore pipeline or facility were to occur on a pad, the extent of the spill likely would be restricted by containment berms. If the spill occurred along the off-pad portion of the pipeline, the area covered may include several acres; if the spill were to enter streams or lakes, a larger area could be affected as the oil spreads over a water surface or is carried down a watercourse. From mid- to late summer, such an occurrence could contact brood-rearing females and their young, as well as potentially large flocks of nonbreeding and post breeding individuals undergoing wing molt.

Ten large spills would be expected as a result of the offshore Beaufort Sea and Chukchi Sea Planning Areas Outer Continental Shelf program over the next 50 years (see Table 4-42). Loons, waterfowl, and shorebirds in onshore habitats are generally at low risk of contacting an offshore spill while nesting, but risk of exposure increases as they leave the mainland nesting areas and concentrate in coastal or marine habitats for brood rearing, molting, or staging. In addition, some species (e.g., red-throated loons) forage almost exclusively offshore and bring food back to their young, so impacts of oil spills may be greater on these species (Eberl and Picman 1993). Likewise, species nesting on barrier islands, such as common eider, gulls, and terns, are at risk when post-nesting individuals join other species in lagoons and other near shore habitats. Substantial numbers of waterfowl occupy Simpson and other Beaufort Sea lagoons, Harrison and Smith Bays, Kasegaluk Lagoon, and Peard and Ledyard Bays in the Chukchi Sea during molt. For example, tens of thousands of long-tailed ducks molting in Beaufort Sea lagoons, far outnumbering other species, are at risk in July and August, and in late August and early September, a large proportion of the Pacific flyway brant population could be exposed to a spill that enters Kasegaluk Lagoon. Substantial numbers of non-breeding, foraging, or staging birds that occupy offshore areas in both the Beaufort and Chukchi seas, when open water beyond the barrier islands is available, could be exposed to an oil spill.

Most brood rearing of loons, swans, and geese occurs on large lakes or coastal saltmarsh. Risk of oil spill contact is much greater for those using the latter habitat. The most important molting area for brant and several other species of geese is on the shorelines and within the Teshekpuk Lake Special Area (Derksen et al. 1979, 1982). An offshore spill could also affect feeding habitats in coastal habitats, such as extensive mudflats in the Colville River Delta, which are used by staging shorebirds. The Colville River delta supports thousands of shorebirds (the most abundant of which is dunlin; Andres 1994) and geese, and hundreds of swans in the fall as they stage and prepare to migrate. The *arcticola* subspecies of dunlin is considered to be highly imperiled (Brown et al. 2001). An oil spill could also contaminate prey populations in foraging areas at any time of year, which could result in secondary impacts to loons, waterfowl, and shorebirds by affecting productivity and/or survival.

During spring migration, substantial numbers of birds moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives available to the birds until open water off river deltas is available in late spring. The most numerous species to use the ice lead system include king eider, common eider, long-tailed duck, and brant. Beaufort and Chukchi sea migrant birds that are moving past the NPR-A also encounter a restricted open water situation as they wait for ice melt to occur further to the east or to the north. Birds that occupying river delta waters and near shore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats are also at high risk as there is little available open water areas that they can relocate to if an oil spill occurs . Major effects on some bird populations during the open water season are expected to follow a spill. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, feeding). Survival and fitness of individuals may be affected and significant population losses may occur. In addition, it is unlikely that all spilled oil would be removed from the environment, and a spill occurring in winter, when birds are virtually absent from the planning area, still may have serious impacts if substantial quantities of oil are entrained in the ice and then released during the following breeding season.

In addition to the potential impacts from spilled oil, the oil spill cleanup process may also affect birds in both the onshore or offshore environments. The presence of large numbers of personnel, boats, and additional aircraft following a spill is expected to displace birds occupying affected habitats for one to several seasons. Cleanup efforts late in the breeding season may disturb brood-rearing, juvenile, molting or staging birds. It is extremely difficult to separate the effects of oiling and disturbance from cleanup activities, but either separately or together they have the potential to influence birds and habitat use by birds (Wiens 1996).

The oil industry is required to have oil spill response and clean-up capabilities, and small spills on lands or waters in the NPR-A or in existing or future North Slope oil and gas fields and other industrial developments are expected to be contained and cleaned up before substantial bird and habitat loss can occur. In addition to mortality through direct contact with oil, some mortality could result from the accumulation of effects of the numerous small spills expected from the operation of any oil field. Indirect impacts to birds through permanent habitat loss would likely be negligible due to the small number of acres likely to be affected. Under the reasonably foreseeable future scenario the amount of oil produced on the North Slope is expected to continue to decrease from historic high levels. As oil production slows, coupled with improvement in spill prevention, control technologies and training, the potential for effects to birds should decline over time. This potential downward trend could be countered, however, if an aging pipeline system led to an increase in pipeline leaks.

Tanker spills of crude oil from oil fields on the North Slope could impact birds in marine habitats along the entire tanker route from the port at Valdez to West Coast refineries and beyond. A large oil spill in the Prince William Sound area, similar to the Exxon Valdez spill in 1989, would impact many thousands of waterfowl and marine birds at any time of the year. Large numbers of loons and waterfowl from the North Slope use Prince William Sound as a migratory stopover or wintering area. The Copper River Delta is a migratory stopover area for millions of shorebirds during spring and fall migration; if an oil spill were to spread to this area, it could impact many thousands of birds. Marine birds and waterfowl could also be impacted by an oil spill in the Gulf of Alaska or in open water or bay habitats along the Pacific Coast of Canada, Washington, Oregon, and California. Oil spills occurring in coastal areas would likely produce greater impacts to birds than a spill occurring several hundred miles offshore, where bird densities are much lower. Spills, such as the Exxon Valdez spill and many smaller spills, have already caused extensive bird mortality in many of these areas. The actual numbers of birds impacted by an oil spill is likely much higher than the number of oiled carcasses recovered, because the carcasses of many oiled birds may never be recovered.

The length of time required for populations to recover and the lingering effects of contamination vary among species.

Any accidental gas releases that occur in the future would likely affect only individual birds that are nearby at the time of the release. Any impacts to bird populations would likely be negligible and would not accumulate.

Abandonment. The ultimate fate of the gravel pads, roads, and airstrips will not be known until closer to the end of the life of the oil and gas fields. Permitting agencies could require that gravel be removed, in part or in total, and the tundra revegetated. If other uses are determined by the permitting agencies to be preferable, the agencies could allow the permittee to leave the gravel pads in place, either revegetated or not revegetated. Removed gravel either would be disposed of or reused for another development. The impacts of abandonment and reclamation of oil and gas fields on birds would be similar in many respects to those incurred by construction activity, although activities occurring in the winter would cause little disturbance or displacement, because most species would be absent from the area. Summer road and air traffic generated by abandonment and rehabilitation activities could cause disturbance, displacement, and mortality to birds that would be similar to, and at the same levels as that caused by traffic during construction and operations. If pads, roads, and airstrips were not revegetated, their value to birds would be lessened. If they were revegetated without removing the gravel, the habitat would not return to its current utility for most birds of the area. If gravel was removed, habitat similar to that currently existing in the area could be created and used by birds, though the precise mix of habitat types would likely not be the same as what prevailed at the time of disturbance. The effects of habitat loss would accumulate, as described above, to the extent that habitats were not, or could not be, restored to their original condition.

Numerous other factors could add to cumulative impacts on bird populations on the North Slope. Subsistence harvest of some species of birds (primarily waterfowl) and eggs continues to impact these species, although overall numbers of birds and eggs taken over their entire range are not known. Aside from direct mortality due to subsistence harvest, the accumulation of lead shot in waterfowl foraging habitat in the Y-K Delta may be impacting waterfowl survival. It is currently illegal to use lead shot while hunting any bird species on the North Slope.

Factors Outside of the North Slope. Wintering grounds and portions of migratory routes of many bird species lie in areas outside of the North Slope, including areas within the U.S. and several other countries, and regulated or non-regulated development in these areas can impact critical bird habitats. Habitat losses in non-breeding areas could be particularly significant for species of concern or species with low population numbers, such as buff-breasted sandpiper. Habitat losses may occur directly from habitat destruction due to development, or from pollution, such as exposure to agricultural pesticides that may reduce the ability of birds to reproduce or may cause direct mortality to birds. Other activities, such as commercial fishing, may also have the potential to cause changes in predator/prey relationships or damage benthic habitats that could affect some marine bird populations. Numbers of wind farms are increasing in many areas of the United States, including Alaska and in many other areas of the world. These wind farms have the potential to cause direct mortality to birds. Disease, such as West Nile virus and avian influenza have the potential to be transmitted to and from the planning area by species that spend a portion of their life cycle in Asia. Impacts related to subsistence hunting and sport hunting in wintering areas and along migratory routes can be additive to the effects of development on the North Slope. Spent lead shot that remains in waterfowl feeding habitat has been linked to lead poisoning for some waterfowl species (Franson et al. 1998). Impacts of subsistence hunting may impact species of concern such as brant, bar-tailed godwit, and threatened eiders as well as many more abundant species. Cumulative effects to birds would be additive and include habitat loss and disturbance related to activities on the migration and wintering grounds that could result in permanent or temporary displacement from preferred feeding and roosting habitats.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Short-term impacts from ice road construction would occur on 231,995 to 456,683 acres during the life of the plan, while impacts from ice airstrips would occur on another 715 to 1,375 acres. Short-term impacts from oil and gas exploration wells would occur on 384 to 768 acres depending on alternative (Table 4-14 in Volume 2), with 456 acres estimated for Alternative B-2, these impacts to bird habitat likely would not accumulate. Long-term impacts to bird habitat from oil and gas infrastructure surface disturbance in the NPR-A would occur on approximately 7,505 to 16,329 acres under the five alternatives, with 8,402 acres estimated for Alternative B-2 (Table 4-14 in Volume 2). These long-term impacts would accumulate. Total, long-term, direct and indirect impacts to vegetation from exploration and development combined would occur on 0.12 percent (Alternative B-1) to 0.26 percent (Alternative D) of the NPR-A. These habitat losses would account for up to 53 percent of the habitat projected to be lost due to development on the North Slope during the next 88 years.

Functional loss of habitat as a result of displacement due to disturbances, could involve a much greater area. Given that the area most likely to be developed for oil under the action alternatives (economic zones 110 and 120, section 4.2.1.2 Volume 2, "Discovery and Development") includes the most important nesting and brood-rearing areas for the majority of the birds in the NPR-A (especially waterfowl and loons) impacts to birds, and their habitats could be much greater than predicted based solely on amount of area disturbed. Because of the importance of these areas, Lease Stipulations/Best Management Practices E-2, G-1, K-2, K-3a and b, K-4a and b, K-6, K-8a and b, and K-11 were developed to provide special restricted surface occupancy protection to bird habitat, though not all of these protections would apply to Alternative D. Still, individuals of many species would be exposed to oil and gas disturbance during the breeding period. Depending on the types and locations of facilities, impacts to birds could accumulate, especially where species are concentrated such as molting lakes and staging areas, and could affect the long-term health of the local population.

The effects to birds and bird habitat from oil and gas development would be least under Alternatives B-1 and B-2, because much of the very high value habitat would be unavailable for leasing under this alternative. The effects would be greatest under Alternative D, since the entire NPR-A would be open to leasing with fewer mitigations than under other alternatives. Impacts to vegetation (bird habitat) and direct disturbance of birds on the North Slope from future oil and gas exploration and development are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past, present, and future oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of habitat impacted by all oil and gas development, and would be additive in nature for the most part. However, depending on oil prices and where and how much oil is ultimately developed in the NPR-A and offshore, there could be synergistic effects on acreage of habitat affected and levels of disturbance to birds in the NPR-A. This would occur if a discovery in the Chukchi or Beaufort sea, and the subsequent transportation system (pipelines) would make economically feasible the development of additional oil or gas fields in the northern part of the NPR-A which would not otherwise have been economically developable. Such a scenario could result in additional development in an area that is important nesting and molting habitat for many species of birds.

Similarly, development in the northern portion of the NPR-A could have a synergistic effect on birds using the Colville River delta, either by providing economic incentive for increased oil/gas development in the latter, or by the need for increased infrastructure or air or ground traffic in the delta to transport oil or gas, or supplies and equipment, to or from the NPR-A. In addition to these areas, the potential exists for development of production facilities or a staging base on private land at Cape Halkett at the northeastern tip of the NPR-A. These private lands do not have the requirement for a three-quarter-mile buffer along the coast. Development on these private lands would potentially impact molting and staging waterfowl (especially brant) in a manner that would be additive, or perhaps synergistic, to effects from development on adjacent BLM-managed lands. Implementation of Alternatives A, B-2, C, or D would not preclude development in the Beaufort Sea as those alternatives, in contrast to Alternative B-1, allow for access to NPR-A lands for transport of Beaufort Sea oil or gas to market. This would represent an additive effect to total development in the NPR-A.

Synergism affecting molting and staging waterfowl, loons and shorebirds could similarly result if development north of Teshekpuk Lake resulted in offshore development being more economically feasible. Such offshore development would likely result in additional habitat and disturbance impacts from developments built onshore in support of offshore activities and from interactions of birds with offshore developments including collisions and oiling. This would most likely affect the Beaufort Sea coastal portions of the NPR-A. This scenario is not possible under Alternative B-1 in which new non-subsistence infrastructure would not be permitted along BLM-managed lands east of Barrow. Synergistic development onshore as a result of offshore development is also severely reduced under Alternative B-2 because none of the Beaufort Sea coastal area in the NPR-A would be available for lease. It would be most likely under Alternative D because no areas would be unavailable for leasing under that alternative and there are fewer development restrictions. It would be less likely under Alternative A because of development constraints and less yet under Alternative C because of development constraints and some coastal lands being unavailable for lease.

Cumulative effects from this plan on birds' distribution and abundance are likely to be long term, lasting as long as the life of the oil and gas fields. Any reduction in breeding as a result of future onshore or offshore development would represent a functional loss of habitat that accumulates and could result in long-term effects on a suite of bird species' productivity and abundance. These impacts would likely be greatest under

Alternative D and lowest under Alternative B-1. The effects of oil and gas activities in the NPR-A would be greatest on those bird species that use the NPR-A in disproportionately high numbers or if their populations are low or decreasing. If climate change over the next several decades were to result in widespread changes in vegetation composition and insect and other invertebrate abundance, disturbance effects of oil and gas activities to birds could be exacerbated through the additive effects of oil and gas activities to habitat, and could extend beyond the life of the oil fields.

Conclusion

It is reasonable to assume that increased development would cause increased disturbance to birds. Although there is no clear indication that disturbance effects have accumulated to the point that they are adversely affecting bird populations, the effects of potential future developments outside of the NPR-A including offshore development in the Chukchi and Beaufort seas would be additive to effects of present and past development. If birds are displaced from prime habitat and disturbance further displaces birds, the effects of displacement and disturbance could result in energetic costs that reduce survival and productivity. These losses of individual birds would accumulate, and could persist as long as development and associated disturbance occur on the North Slope. Increases in the predation of birds and nests would be expected in areas of increased human activity as predators tend to concentrate in areas of human development on the Arctic Coastal Plain. Although there is no clear indication that predator effects have accumulated to the point that they are adversely affecting bird populations, the effects of potential future developments outside of the NPR-A would be additive to effects of present and past development. If birds are killed or nests predated due to increased numbers of predators in the vicinity of human infrastructure losses of individual birds would accumulate, and could persist as long as development occurred on the North Slope. Bird mortality from collisions with buildings, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore and offshore oil and gas development is likely to persist into the future, and is expected to increase with increasing levels of development. The oil and gas industry has developed and implemented anti-collision practices, including providing better lighting of facilities, burying power lines, and attaching power lines to pipelines, in an attempt to reduce the number of bird collisions oil and gas infrastructure. Losses from collisions with offshore infrastructure are expected to be small and would not be expected to significantly affect bird populations. However, if birds are killed due to increased collisions with oil and gas infrastructure, losses of individual birds would accumulate, and could persist as long as development occurred on the North Slope. Impacts to birds from all of the above listed sources would have the potential for a greater negative effect and increased accumulated effect if the activity occurs in areas of high bird densities, in habitats of limited sized used by specific species of birds or on species with declining populations.

Although direct habitat loss from cumulative oil and gas development on the North Slope would affect only a small proportion of the total area, indirect habitat loss, or functional loss, could result from long-term displacement of birds from the vicinity of oil and gas activities and could involve a much larger area. Future gas and both conventional and unconventional oil exploration and development between the Colville and Canning rivers, in addition to construction of an Umiat road and a commercial gas pipeline, would increase the amount of activity bird populations on the North Slope are subjected to. Offshore leases in the Beaufort and Chukchi seas could expose birds to additional activities related to oil and gas development (through offshore drilling platforms, onshore facilities to support offshore leases and through increased aircraft and marine vessel traffic). Future development in the NPR-A could expose birds to disturbance during sensitive nesting, brood-rearing, molting and staging periods.

Development of onshore oil resources in the western portion of the NPR-A or offshore development in the Beaufort or Chukchi seas would result in construction of one or more additional aboveground pipelines that would pass through the NPR-A. Construction of a pipeline from (or through, in the case of offshore development) the western portion of the NPR-A east to the Kuparuk River Unit, or a southern pipeline route connecting to the Trans-Alaska Pipeline System Pump Station 2, may temporarily disturb birds. Pipelines associated with any of these oil developments may or may not have roads associated with them, but if roads are built, the expected effects would increase.

Climate change may eventually lead to large shifts in the composition of Arctic tundra toward increased shrub height and cover extent, tree encroachment north of the Brooks Range and increased grass and sedge species (Chapin et al. 1995; Naito and Cairns 2011; Sturm et al. 2001; Walker et al. 2006; Scenarios Network for Alaska Planning 2011). These changes in vegetation would directly impact the amount and types of habitat available to tundra nesting birds. Predicted warmer soil temperatures are likely to increase thermokarst, and increases in sea level may inundate low-lying tundra areas, increasing salt marsh, aquatic, and wet tundra vegetation types and erosion of coastal bluffs (Arctic Climate Impact Assessment 2004) causing changes to or elimination of nesting and feeding habitat for birds. Such impacts of climate change could accumulate with any changes in soil thermal regimes that might occur as a result of past and future non-oil and gas and oil and gas activities in and near the NPR-A, potentially leading to synergistic impacts to bird habitat.

Impacts to bird habitat may accumulate from the following sources: past non-oil/gas activities, non-oil/gas activities from now until about 2100, past oil/gas activities outside of the NPR-A, future conventional oil/gas activities onshore and offshore of the North Slope including the NPR-A, future unconventional oil activity east of the NPR-A, construction of a road and pipeline(s) from Umiat to the Dalton Highway, and construction of a commercial gas pipeline. All future impacts are additive to the impacts to bird habitat that have accumulated in the past and persist today, but in the context of the entire North Slope west of the Canning River, these cumulative impacts would be relatively small. Based on impacts to 42,050 acres that could still persist in 2100 (Table 4-40), direct impacts to habitat would occur on 0.1 percent of the North Slope west of the Canning River. This estimate does not take into account the quality of habitat that would be impacted on the North Slope. It is likely that the focus of future oil exploration and development would remain relatively near to the coast, and much gas development will likely occur in the same area. Future gas exploration, however, may be concentrated further south in the foothills. A wide variety of habitat types have variable value to birds could ultimately be affected.

4.8.7.9 Terrestrial Mammals

Onshore and offshore oil and gas exploration and development and their support activities onshore are the primary contributing activities in terms of cumulative effects on mammals of the North Slope west of the Arctic National Wildlife Refuge, an area of 41.6 million acres, between 1900 and 2100. The primary effects from oil and gas exploration include habitat loss and disturbances that displace mammals from preferred habitat areas or otherwise affect their behavior. An oil spill could not only affect habitat, but also cause direct harm or mortality to mammals due to its toxic effects.

Other factors that contribute to the cumulative effects on mammals on the North Slope include permitted activities such as non-oil and gas-related overland moves and development, scientific data gathering, recreation, and subsistence and sport hunting. In addition, an analysis of cumulative effects to migratory mammals cannot ignore effects to animals on migratory routes or wintering areas, where impacts could be independent of activities on the North Slope. Mammal populations can show substantial changes between years and over decades, regardless of influence by these change factors. As a result, without controlled experimentation, it may be difficult to determine if effects from these change factors are accumulating at the population level, or if observed population fluctuations merely reflect short-term shifts in population numbers.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development. Non-oil and gas activities by government agencies and non-government research efforts have had minor impacts on terrestrial mammals. The amount of such non-oil and gas activity on the North Slope is relatively low, and impacts consist primarily of short-term disturbance to individual animals. Aircraft disturbance of terrestrial mammals associated with resource inventory and survey activities (particularly by helicopter traffic) would be expected to have short-term effects on some caribou, moose, muskoxen (particularly cow/calf groups) and bears, with animals being briefly displaced from preferred feeding and resting areas when aircraft disturbances occur nearby. Unless they were to occur multiple times per day and over many days, it is not expected that these types of disturbances would have effects that persist and accumulate.

Approximately 15,800 to 25,000 caribou from three North Slope herds (Teshekpuk Caribou Herd, Western Arctic Herd and Central Arctic Herd; Carroll 2005, Dau 2005, Lenart 2005, Stephenson 2005) are harvested annually by subsistence and sport hunters, most of whom reside and hunt outside the North Slope, including northwestern Canada. Caribou of the Teshekpuk Caribou Herd use the NPR-A more than the Western Arctic Herd or Central Arctic Herd, and the Teshekpuk Caribou Herd is the herd most often harvested by residents of Atqasuk, Barrow, Nuiqsut and Wainwright. The 2006-2007 and 2007–2008 Teshekpuk Caribou Herd harvests were estimated at 4,829 and 4,102 caribou, respectively (Parrett 2010). This is an annual harvest rate of 6.4-7.5 percent of the herd at its current population level. Most of this harvest is attributable to subsistence hunters; harvest by sport hunters is generally low and mostly confined to the Colville River drainage. The Western Arctic Herd, because of its large size and large annual range, is important to the subsistence economies of many rural villages, mostly south of the North Slope. Subsistence harvest was estimated at

15,000 for the 2004-2005 year and 14,000 for 2005-2006 (Dau 2007b). The Western Arctic Herd is also hunted by people who reside outside the herd's range. These non-local hunters harvested at least 697 Western Arctic Herd caribou during the 2002-2003 regulatory year and at least 549 in the following year (Dau 2005b). Local subsistence hunters from Nuiqsut and Kaktovik and non-local hunters harvest about 800-900 Central Arctic Herd caribou each year (Lenart 2007b, 2010). Non-locals hunt mostly along the Dalton Highway. Since caribou populations on the North Slope appear healthy and are stable or increasing in numbers, hunter harvest is likely replacing some of the loss of animals that would occur due to natural mortality, and cumulative effects are not inhibiting achievement of management goals for the three herds whose ranges overlap the NPR-A.

Moose and muskox populations on the North Slope have fluctuated dramatically over the last 15-20 years, due primarily to natural causes, and hunting regulations have varied accordingly so the effects of hunting are not additive to natural losses. These two species represent only a small fraction of terrestrial mammal harvest on the North Slope.

Non-oil and gas development at former military sites and in villages has caused the loss of habitat and increased levels of disturbance. Distant Early Warning-Line sites and other military facilities, villages, public roads, airstrips, and other non-oil and gas infrastructure have been developed using gravel pads or on bare ground cleared of vegetation. Approximately 2,500 acres (1,800 acres of village and public facilities, and 700 acres of military facilities; section 4.8.7.5) of the 50.5 million acre North Slope have been impacted, and this loss of habitat is likely to persist into the indefinite future. These villages and developments are within or near important mammal use areas, including important summer, winter, and migration ranges for the Teshekpuk Caribou Herd, Western Arctic Herd, and Central Arctic Herd caribou. Development has increased disturbance effects to mammals through human activity in the vicinity of villages.

These effects of villages and military facilities, coupled with subsistence and sport hunting pressure, have resulted in effects to caribou that persist today (i.e., the gravel and human activities remain). Nonetheless, due to harvest management by the Federal Subsistence Board and the State of Alaska's Board of Game and the relative extent of village development versus oil field development, these effects are considered minor for the North Slope as a whole compared to the habitat alteration and disturbance effects of the oil fields. This is especially true for the Central Arctic Herd, whose calving and summer distribution overlaps considerably with current oil field development, but is less so for the Teshekpuk Caribou Herd and Western Arctic Herd. The latter two may have been affected more by past/present development associated with villages than that associated with oil fields, but to date all these effects on the Teshekpuk Caribou Herd and Western Arctic Herd have been considered minor.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration Drilling. Loss of habitat and disturbance (including noise) are the two primary factors associated with seismic activities and exploration drilling that could affect mammals on the North Slope. Until the past two decades, seismic testing resulted in few conflicts with caribou in Arctic Alaska (National

Research Council 2003). Seismic surveys on the summer ranges of the Central Arctic Herd and Western Arctic Herd caribou were conducted during winter, when the animals were rarely present. In a few cases, winter seismic survey areas at times overlapped with Central Arctic Herd, Teshekpuk Caribou Herd, and Western Arctic Herd winter ranges, but impacts were probably limited to small groups of animals. In the past 20 years, exploration has increased in the NPR-A and has extended into the foothills of the Brooks Range to the east of the NPR-A. These areas are within the winter ranges of the Teshekpuk Caribou Herd and Central Arctic Herd. It is likely that these activities briefly disturbed and displaced Teshekpuk Caribou Herd caribou near seismic grids, exploration drill sites, and along ice roads and aircraft transportation routes. However, it has been assumed that these effects did not persist after exploration was completed, and there was no consequential effect on the abundance or productivity of the caribou. This assumption has not been scientifically tested, however, and conditions for winter survival vary from year to year. It is possible that this disturbance could have an additive effect on natural winter mortality and could disproportionately impact young of the year and pregnant cows. Such an impact over several years could accumulate and reduce the productivity of the caribou herds involved.

Much of the Arctic Coastal Plain and nearly all of the NPR-A have undergone seismic surveys since the 1940s. Rolligons and tracked vehicles used during seismic exploration have left some tracks on tundra habitats that are still visible today and could make the habitat unsuitable for some mammal species. Only a small portion of older seismic and camp move trails is still in evidence (about 5 percent; Jorgenson et al. 2010). Use of lightweight vehicles, dispersing traffic patterns, minimizing sharp turns, and requiring surveys to be done when there is adequate snow and frost cover to protect the tundra have helped to minimize damage to vegetation used by caribou and other terrestrial mammals (Walker 1996).

Other sources of habitat loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Based on a report by the National Research Council (2003), in 2001 approximately 1,700 acres had been impacted by these sites in the past, and 1,130 acres (66 percent) of disturbed areas were still evident. Most of these sites were developed before 1977, thus, their effects on the vegetative landscape have persisted for decades, and are likely to persist for several more decades. As industry has shifted towards use of ice roads and ice pads during exploration, loss of mammal habitat has slowed greatly. Ice roads and ice pads have minor effects that could impact mammal habitat for several years, but would be unlikely to accumulate because their effects are short-term and of limited geographic scope.

Oil and Gas Development and Production. Loss of terrestrial mammal habitat from gravel road and pad construction and gravel mining, and disturbance associated with development and production activities are effects to mammals that have occurred in the past and that persist today. Peat and gravel roads, gravel pads, and gravel mines have caused the direct loss of habitat, and also have led to the indirect loss of habitat from road dust and alteration of natural drainage patterns. Through 2001, over 500 acres of peat roads still showed evidence of disturbance, even though most of these roads were constructed over 30 years ago. For the North Slope as a whole, it has been estimated that as of 2001 gravel had been used to construct about 8,998 acres of roads and pads in the onshore oil fields, 564 acres of the Dalton Highway, 1,765 acres had been impacted by other oil field related disturbances, and gravel mines had impacted another 6,364 acres (Table 4-38). Approximately 4,500 acres of gravel mines had been rehabilitated but only 70 acres of gravel pads (National Research Council 2003). However, rehabilitation of gravel mines produces primarily fisheries habitat, not the tundra vegetation that is habitat for terrestrial mammals, and rehabilitation of gravel pads has produced mixed results that have not restored areas to original conditions. Thus, total onshore habitat loss and disturbance through 2001 is thought to have amounted to about 17,691 acres (Table 4-38; 0.04 percent of the North Slope east of the Arctic National Wildlife Refuge). Additional habitat alteration due to dust and moisture regime changes has occurred on about 104,000 acres (6:1 ratio, National Research Council 2003).

Motorized traffic along about 400 miles of roads has disturbed, impeded the movement of, or displaced caribou and other terrestrial mammals (National Research Council 2003). Disturbance of caribou from road traffic associated with pipelines has been shown to cause short-term displacement of caribou within about 1 mile of the road (up to 2.5 miles for parturient females and calves and subsequent abandonment of some calving habitat; Dau and Cameron 1986). Road traffic has delayed the successful crossing of pipelines and roads by caribou, and could have adverse energetic effects on some animals. Grizzly bears, wolves, Arctic foxes, and other mammals generally seem to cross roads more easily than caribou.

Road construction has increased access to previously undeveloped areas and has increased hunting pressure on terrestrial mammals from public and subsistence hunters in more remote regions of Alaska. Hunting pressure and harvests have increased for many wildlife species near the Trans-Alaska Pipeline System since its construction but have not produced adverse population effects (Trans-Alaska Pipeline System Owners 2001).

Oil development in the Prudhoe Bay-Kuparuk River Unit area has caused displacement of Central Arctic Herd caribou from a portion of the calving range, with a shift in calving distribution away from the oil fields (Nellemann and Cameron 1996, Lawhead 1997, Cameron et al. 2002 and 2005, National Research Council 2003). The reduction in calving habitat use near oil development facilities could eventually limit the growth of the Arctic caribou herds within their present ranges and prevent the herds from reaching the maximum population size that they could achieve without the presence of development. It is possible that such an effect would not be apparent, however, because natural changes in the distribution and productivity of the herds may influence the abundance and growth of caribou populations over and above the effect of reduced habitat use caused by cumulative oil development.

For example, the Central Arctic Herd caribou population estimate decreased from 23,000 in 1992 to 18,100 animals in 1995, but then rose to 31,857 caribou in 2002, 67,000 in 2008, and 70,034 in 2010. However, recent information on the body weights of Central Arctic Herd cow caribou (and their calves) that calve west of the Sagavanirktok River, compared with Central Arctic Herd cow caribou and calves from calving grounds east of the river, suggested that disturbance displacement of cow caribou may be affecting Central Arctic Herd caribou productivity (Cameron 1994, Nellemann and

Cameron 1996, Cameron et al. 2002 and 2005, Arthur and Del Vecchio 2006). On the other hand, differences in densities and movements between segments of the Central Arctic Herd caribou on the oil fields and east of the fields may have contributed to the decline (Cronin et al. 1997). The National Research Council (2003) suggested that the combined effects of industrial activity and infrastructure, and the stress imposed by insects, might have contributed to the reduction in size of the herd seen from 1992 through 1995. Cronin et al. (2000) argued that population-level impacts from oil field development have not occurred for this herd. However, comparing the higher growth rate of the Teshekpuk Caribou Herd to the growth rate of the Central Arctic Herd, Griffith et al. (2002) and Cameron et al. (2005) suggested that the Central Arctic Herd might have been influenced by development infrastructure after 1987.

The alteration of over 17,000 acres of tundra habitat in the Prudhoe Bay area may have the potential to affect the distribution and abundance of terrestrial mammals other than caribou (e.g., muskoxen; Garner and Reynolds 1986; Clough et al. 1987), but such effects have not been observed (bears; Shideler and Hectel 2000) with the possible exception of Arctic foxes, which apparently have increased in numbers near the oil fields (Burgess et al. 1993). Muskoxen have continued to expand their range westward across the North Slope from an introduced population in the Arctic National Wildlife Refuge (but have declined due to increased predation in recent years). There have been no apparent effects on wolves or other terrestrial mammal populations associated with this development.

Spills. The National Research Council's Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope found that most spills to date have had only local effects, and that there is no evidence that effects of spills have accumulated (National Research Council 2003).

Summary of Past and Present Effects and Their Accumulation

Approximately 2,500 acres of habitat have been directly impacted by non-oil and gas development on the North Slope and those impacts continue to persist. Oil and gas activities have caused an additional habitat loss or alteration of over 17,000 acres that persist today. Since most of these impacts are associated with ongoing residential and non-oil and gas commercial development, or oil and gas activities, these impacts to habitat are additive to future impacts and would be likely to persist for several decades or more in the absence of an active reclamation program.

Oil and gas development has altered the distribution of female Central Arctic Herd caribou during the calving season and interfered with caribou movements between inland feeding areas and coastal insect-relief areas. Female caribou may also experience lower parturition rates when in close proximity to oil field development. It has also been suggested that declines in Central Arctic Herd caribou productivity in the early 1990s may have been the result of additive effects of oil field development and high insect activity, although populations of Teshekpuk Caribou Herd and Central Arctic Herd caribou have increased between the mid-1970s and 2008. Thus, disturbance of caribou due to oil field development may adversely affect caribou populations, but these effects are not readily apparent based on population trends. The Western Arctic Herd, whose range does not overlap the current oil fields and whose insect-relief habitat is not on the coastal plain, increased in numbers until about 2003. Since then, population estimates suggest a stable or slowly declining population.

Other mammal populations (e.g., moose, muskox, fox and grizzly bear) have been little affected, or some may even have benefited from development on the North Slope. Subsistence and recreational hunting pressure has likely increased from historic levels due to increases in human populations and better access to the North Slope. Still, based on subsistence harvest surveys, subsistence harvest of mammals has been relatively stable since the early 1990s. Based on population trends of game mammals on the North Slope, neither hunting nor other human activities appear to be adversely affecting mammal populations.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities on the North Slope, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, overland moves by transport vehicles, and use of off-highway vehicles such as four-wheel vehicles and snowmachines, would continue to disturb mammals and cause the loss of minor amounts of mammal habitat. In most cases, loss of habitat would be temporary, lasting only a few years. Distant Early Warning-Line and other military sites, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future. Furthermore, villages are likely to increase in size causing the loss of additional habitat. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 (section 4.8.2.1) and then level off for the remainder of the 21st century.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration Drilling. Based on past seismic activity on the North Slope, the BLM assumes continuation of the recent experience of three to four seismic crews active there each winter and that approximately 86,400 acres would be covered annually by seismic activities, including camp moves, on the North Slope with 125 acres of that total still showing moderate to high levels of disturbance a decade later. Other sources of habitat loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. These have been replaced in recent years by ice roads, airstrips, and drilling pads to reduce the costs and environmental effects of gravel construction (Johnson and Collins 1980, Hazen 1997). Impacts from ice roads and pads are short-term (Yokel et al. 2007) and are not expected to accumulate. As a result, only a small amount of habitat is likely to be affected long-term by exploration activities (i.e. seismic). However, if climate warming shortens the winter season to the point where ice roads are not economically feasible for all exploration drilling, the alternatives may cause greater habitat impacts than current practices. In this case, exploration and climate change would have synergistic effects on habitat loss from exploration activities.

Oil and Gas Development Activities

Overview. Development activities that could contribute to cumulative effects to mammal habitat on the North Slope include oil and gas development, including the NPR-A; federal and State offshore oil and gas development (through the construction of supporting onshore infrastructure); state and Native corporation onshore oil and gas development, both conventional and unconventional; oil and gas transportation, including commercial gas pipelines; and road construction. All of these activities involve construction of infrastructure that would destroy habitat within the immediate footprint of the project and indirectly affect habitat through dust, flooding, changes in natural drainage patterns, snow drifting, increased water and air pollution, and oil and chemical spills.

The increase in the amount of area disturbed by oil and gas development on the North Slope has slowed in recent years. Before 1988, the oil field road network grew by about 24 miles per year, but only 3 miles per year since 1988. The average rate of all gravel placement was about 421 acres per year before 1988, and only 42 acres per year between 1988 and 2001 (National Research Council 2003; Table 4-38). Approximately 462 more acres have been covered by gravel between 2001 and 2012. If the current rates continue into the future for areas outside the NPR-A, the ratio of gravel mine acres to gravel footprint acres remains about 5:1 (see section 4.2.1.2. "Discovery and Development" (Volume 2), and assuming Alternative D is implemented within the NPR-A, about 21,800 additional acres would be covered by gravel, and 4,350 acres impacted by gravel mines, between 2012 and 2100. Approximately 16,700 acres would be indirectly affected by dust, changes in hydrology, and thermokarst. The specific sources of habitat loss through future development are detailed below.

Umiat Road and Pipeline. For this analysis, it is assumed that a road and pipeline(s) up to 102 miles long would be built between Umiat and the Dalton Highway. The footprint of the road and ancillary facilities would be almost entirely outside of the NPR-A and is estimated at 850 acres (Table 4-40) with material sites impacting an additional 175 acres. An oil pipeline along the same route would likely be above ground, whereas a gas pipeline would be buried and would affect about 185 acres long term.

Chukchi Sea Development. Potential onshore facilities to support offshore development in the Chukchi Sea include a staging base, a drilling waste disposal facility, a pump station, a gas compressor station, administrative, maintenance and housing infrastructure, marine dock, airstrip and connecting roads. If built, these would probably be at one concentrated site, near the coast, and relatively small in size. If a pipeline is built east across the NPR-A and on to the Trans-Alaska Pipeline System, covering about 300 miles, it would add little long-term impacts to vegetation. Total acreage affected by gravel of all these facilities is estimated to be less than 100 acres, with another 20 acres of material sites. However, if a road were to be built along the pipeline route, the total impact may add up to 3,000 acres. Furthermore, a pipeline across the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in acres of vegetation affected in the NPR-A.

Beaufort Sea Development. Offshore development in the Beaufort Sea would require onshore processing facilities if offshore platforms were too far from the coast for transport to shore of multi-phase produced fluids. If this becomes the case, the acres of habitat destroyed by gravel placement would be few, and probably negligible in the context of other potential future activities. Regardless, up to 85 miles of onshore pipelines would be required, affecting less than one acre of total tundra habitat. This would not be the case, however, under Alternative B-1, which would not allow permanent infrastructure to come ashore along the Beaufort Sea coast of the NPR-A.

Commercial Gas Pipelines. Construction of gas pipelines would have long-term effects on up to 2,200 acres of tundra habitat. This is likely an overestimate since it assumes impacts to 100 percent of 100-foot permanent rights-of-way. Actual gravel footprint is estimated at only 350 acres, with an additional 35 acres of new material sites. All of this would occur to the east of the NPR-A within the range of the Central Arctic Herd and on the eastern margins of Teshekpuk Caribou Herd range. A much greater impact to habitat from this pipeline would be the area affected by the gas development that a pipeline would make possible (already analyzed under all alternatives) within the NPR-A and to the east.

Conventional Oil and Gas Development between the Colville and Canning Rivers. The increase in area disturbed by oil and gas development on the North Slope has slowed in recent years (above). If the current rates continue into the future for areas east of the NPR-A and the ratio of gravel mine acres to gravel footprint acres remains about 5:1, about 3,750 additional acres of habitat would be destroyed for construction of pads, roads and airstrips through the year 2100 and 750 acres by gravel mines. About 27,000 acres (6:1 ratio) would also be indirectly affected by dust, changes in hydrology, and thermokarst. The area between the Colville and Canning rivers represents much of the range of the Central Arctic Herd. In some winters, this area is also important habitat for some Teshekpuk Caribou Herd caribou.

Unconventional Oil and Gas Development between the Colville and Canning Rivers. There are many challenges to this type of development on the North Slope, but for this cumulative analysis it is assumed that unconventional oil and gas development will become viable on better drained lands south of Prudhoe Bay and near the Dalton Highway. It is further assumed that this development will result in destruction of about 3,600 acres of tundra habitat over the next 15 years. As for the case of conventional oil above, the area involved here substantially overlaps the range of the Central Arctic Herd, and partially overlaps the winter range of the Teshekpuk Caribou Herd.

Proposed Road to Access the Ambler Mining District. The State of Alaska is in the beginning phase of planning for access to the Ambler Mining District, which is on the south edge of the Brooks Range in the Kobuk River watershed. Multiple options for access routes including all-season gravel roads and railroads are being studied at this time. The road options would either connect to the Dalton Highway to the east or to a port somewhere on the western coast of Alaska. A railroad would have to begin from current rail in the vicinity of Fairbanks and Nenana. Most of these options would cut across the fall and spring migration path of the Western Arctic Herd, and some would also affect Western Arctic Herd wintering habitat. An estimate of acres of caribou habitat lost to a proposed road cannot be made at this time because the preferred option has not been chosen, but any loss due to a proposed road would accumulate with habitat losses due to developments within the Western Arctic Herd range in the NPR-A.

Thus impacts to mammal habitat may accumulate from the following sources: past non-oil/gas activities, non-oil/gas activities from now until about 2100, past oil/gas activities outside of the NPR-A, future conventional oil/gas activities onshore and offshore of the North Slope including the NPR-A, future unconventional oil activity east of the NPR-A, construction of a road and pipeline(s) between Umiat and the Dalton Highway, construction of commercial gas pipelines, and for the Western Arctic Herd only, an access road to the Ambler Mining District. All future impacts are additive to the impacts to habitat that have accumulated in the past and persist today, but in the context of the entire North Slope west of the Canning River, these cumulative impacts would be relatively small. Based on impacts to 42,050 acres that could still persist in 2100 (Table 4-40), direct impacts to habitat would occur on 0.1 percent of the North Slope west of the Canning River. This estimate does not take into account the quality of habitat that would be impacted on the North Slope. It is likely that the focus of future oil exploration and development would remain relatively near to the coast, and much gas development will likely occur in the same area. Future gas exploration, however, may be concentrated further south in the foothills. A wide variety of habitat types could ultimately be affected.

Disturbance

Overview. Although direct habitat loss from cumulative oil and gas development on the North Slope would affect only a small proportion of the total area, indirect habitat loss, or functional loss, could result from long-term displacement of wildlife from the vicinity of oil and gas activities and could involve a much larger area. Future gas and both conventional and unconventional oil exploration and development between the Colville and Canning rivers, in addition to construction of an Umiat road and a commercial gas pipeline, would increase the amount of activity within the Central Arctic Herd caribou range. Future offshore leases in the Beaufort and Chukchi seas could expose Teshekpuk Caribou Herd and Central Arctic Herd caribou to additional activities related to oil and gas development (through onshore facilities to support offshore leases). Future leases in the NPR-A could expose a large number of the Teshekpuk Caribou Herd caribou to exploration and development activities on their summer and winter grounds, and during migration. Animals from the Western Arctic Herd caribou would also be exposed to development activities in their summer range. Other mammal species would also be affected to the extent their ranges overlapped with these activities.

Development of onshore oil and gas resources in the NPR-A or offshore development in the Beaufort or Chukchi seas would result in construction of one or more additional aboveground pipelines that would pass through the NPR-A. Construction of a pipeline from (or through, in the case of offshore development) the western portion of the NPR-A east to the Kuparuk River Unit, or a southern pipeline route connecting to Trans-Alaska Pipeline System Pump Station 2, may temporarily disrupt movements of Central Arctic Herd and Teshekpuk Caribou Herd caribou. Movements of Teshekpuk Caribou Herd and Western Arctic Herd caribou from wintering habitat to calving grounds, or from summer habitats to wintering grounds, could also be temporarily disrupted. However, pipelines associated with any of the above oil developments would have either no permanent roads associated with them, or roads would be built with a minimum separation from pipelines of 500 feet, and should therefore have minimal effects on caribou movements once construction was completed (Lawhead et al. 2006). Gas pipelines would be buried, so disturbance effects from them would be limited to the construction period.

Whatever effects might occur from any pipeline in the NPR-A could be additive to effects on caribou movement (especially those of the Western Arctic Herd) from developments related to the Red Dog Mine, potential coal mining activity on private lands to the west of the NPR-A, or an access road to the Ambler Mining District south of the Brooks Range. In addition to additive effects, one or more pipelines coming from (or through, in the case of offshore development) the western portion of the NPR-A could have a synergistic effect on caribou by making additional development in the NPR-A more economically viable in the vicinity of the pipeline. Oil and gas development offshore and adjacent to the Central Arctic Herd and Teshekpuk Caribou Herd caribou ranges might include offshore pipelines that would come onshore within the Teshekpuk Caribou Herd caribou range and connect with the facilities at Kuparuk. Potential offshore oil development adjacent to the Teshekpuk Caribou Herd and Central Arctic Herd caribou ranges could result in increased surface vehicle traffic that would disturb caribou along transportation corridors that would connect offshore oil discoveries with the existing infrastructure. Development might also increase disturbance of caribou by ground vehicles and air traffic in insect-relief areas along the coast, and perhaps reduce the seasonal use of coastal areas by cows and calves.

The reduction in calving habitat use near oil development facilities could eventually limit the growth of the Arctic caribou herds within their present ranges and prevent the herds from reaching the maximum population size that they could achieve without the presence of development. It is possible that such an effect would not be apparent, because natural changes in the distribution and productivity of the herds may influence the abundance and growth of caribou populations over and above the effect of reduced habitat use caused by cumulative oil development. Alternatives A, C and D would permit activities within the Teshekpuk Caribou Herd caribou calving grounds and Alternatives C and D would permit activities within a portion of the Western Arctic Herd caribou calving grounds; therefore, calving Teshekpuk Caribou Herd or Western Arctic Herd caribou could be exposed to oil and gas development facilities and activities at a time of year when they are most sensitive to disturbance. A broad-scale analysis of resource selection functions for the Teshekpuk Caribou Herd (Wilson et al. MS submitted) indicates that the landscape characteristics amenable to calving are primarily concentrated in the area north, east, and south of Teshekpuk Lake. This suggests that if Teshekpuk Caribou Herd females are displaced from part or all of the current calving area, parturient females would be unlikely to find similar areas elsewhere across their range. This situation could result in reduced calving success and negatively affect the Teshekpuk Caribou Herd at the population level.

Oil and gas development within the NPR-A could expose summering Western Arctic Herd caribou to noise and disturbance impacts. If development occurred in the southern part of the NPR-A, some Western Arctic Herd animals could be exposed to development activities during the insect season and normal movement patterns could be disrupted. This herd is not currently exposed to oil and gas development activities in any other part of its primary range, but portions of the herd cross the Red Dog Mine haul road during migration. Therefore, relatively minor cumulative impacts to the Western Arctic

Herd caribou would exist and development in the western portion of the NPR-A could increase these impacts further. These effects on Teshekpuk Caribou Herd, Central Arctic Herd, and Western Arctic Herd caribou would accumulate with other past effects on these herds, although the likely magnitude of these effects is difficult to ascertain given recent increases in herd size. These three herds have displayed similar growth trajectories between 1975 and 2000, with maximum long-term growth rates of 13 percent, 10.3 percent and 9.5 percent, respectively (Griffith et al. 2002). Of these, the Central Arctic Herd has experienced oil and gas development over much of its summer range, and yet has displayed similar growth. In more recent years, the Teshekpuk Caribou Herd and Central Arctic Herd have continued to grow, whereas the Western Arctic Herd has begun to decline.

Oil and gas development within the NPR-A could for the first time introduce such infrastructure and activities into the winter range of a North Slope caribou herd (Teshekpuk Caribou Herd). Previously, no North Slope caribou herd has been exposed to oil and gas activities year round. The Teshekpuk Caribou Herd has experienced seismic exploration and activities near villages for many years, and some herd members on the periphery of the range have been exposed to oil field facilities in some years, but there is no evidence as yet of adverse effects other than increased hunting mortality for those animals close to villages. It is not known what population effects might occur if the majority of the herd were to have year-round contact with oil and gas facilities and activities. Despite the current lack of evidence regarding adverse effects from seismic exploration and village contact, negative effects on caribou energy budgets during winter could result from this new situation. Such an effect could be manifested through increased winter mortality itself, or a reduction in calf productivity. Effects during the winter could interact cumulatively with disturbance and displacement effects during summer to result in an additive or even synergistic effect on caribou productivity.

The alteration of over 17,000 acres of tundra habitat in the Prudhoe Bay area since 1968 has the potential to affect the distribution and abundance of terrestrial mammals other than caribou, (e.g., muskoxen; Garner and Reynolds 1986; Clough et al. 1987), but such effects have not been observed (bears; Shideler and Hectel 2000) with the possible exception of Arctic foxes, which apparently have increased in numbers near the oil fields (Burgess et al. 1993). Muskoxen have continued to expand their range westward across the North Slope from an introduced population in the Arctic National Wildlife Refuge (but have declined due to increased predation in recent years). There have been no apparent effects on wolves or other terrestrial mammal populations associated with this development.

Muskoxen populations expanding westward from the 1969 reintroduction at Barter Island reached the NPR-A by at least 1998, and one group appeared to be establishing itself in the NPR-A by 2004. In recent years, muskoxen from the Cape Thompson population have expanded eastward into the southern part of the NPR-A. It is still unclear how muskoxen may ultimately use the available habitats within the NPR-A. Danks (2000) suggested that potential wintering and summering habitat for muskoxen are largely disjunct in the NPR-A, and the movements of the groups currently there may represent a search for the best combination. Predation, oil and gas development, and climate change may all combine to have additive or perhaps synergistic effects on muskoxen establishment and distribution. At present, predation alone appears to be the limiting factor on muskoxen success in the current oil fields and the NPR-A.

The increase in the number of development facilities on the North Slope would be expected to increase the number of negative interactions between humans and grizzly bears, and to result in the loss of bears because of their attraction to human refuse. These interactions could eventually result in a decline in grizzly bear abundance near development areas. It is also expected that cumulative oil development on the North Slope would result in an increase in the abundance of Arctic or red foxes near development areas, which could affect tundra-nesting birds and molting waterfowl and could also pose a health hazard to humans through the spread of rabies and other diseases among the growing fox population. Contemporary efforts to minimize the amount of refuse available to mammals, if continued as expected, should lead to a long-term decline in fox and other mammal populations near oil fields.

Umiat Road and Pipeline. For this analysis, it is assumed that an east-west road and pipeline(s) about 100 miles long would be built between Umiat and the Dalton Highway. An oil pipeline along the same route would likely be above ground, whereas a gas pipeline would be buried. These facilities would cut across north-south migration paths and could potentially affect some individuals of each of the Western Arctic Herd, Teshekpuk Caribou Herd and Central Arctic Herd during some autumn and spring migrations. Construction of any of these facilities would probably begin too late in the fall/winter to affect fall migration, but could still be ongoing during spring migration. Once built, a gas pipeline would be buried and have no effect, although air or ground vehicle traffic meant to monitor the pipeline might have disturbance effects on caribou. An oil pipeline would be above ground and may affect movements of naïve individuals or herds (i.e., Western Arctic Herd and Teshekpuk Caribou Herd), but if elevated appropriately and separated adequately from the road, the pipeline would not likely present a long-term, cumulative effect on either herd because of their ability to habituate to some pipelines and roads as evidenced by the Central Arctic Herd's response to the Trans-Alaska Pipeline System/Dalton Highway corridor.

The road would, however, provide increased access to caribou by non-local hunters, and if hunting were not appropriately managed this could result in cumulative mortality. Also, caribou may adapt to the presence of a road in a way that does not substantially affect the herd, but may have a substantial effect on subsistence hunters that rely on specific paths of movement by migrating caribou.

Chukchi Sea Development. Onshore facilities to support offshore development in the Chukchi Sea would likely be concentrated at one site, near the coast, and cover a relatively small area. Disturbance of caribou by these facilities would be minor, especially after caribou have had a year or more to habituate to their presence. Following that, these disturbance effects would not likely accumulate with disturbance from other portions of a herd's range. If a pipeline and road were built east across the NPR-A, they would have effects similar to those of the Umiat road and pipeline but on the Teshekpuk Caribou Herd and Western Arctic Herd rather than Teshekpuk Caribou Herd and Central Arctic Herd. The portion of that pipeline and road extending east from the NPR-A to the Trans-Alaska Pipeline System would likely have effects subsumed by (as opposed to being additive to) those of the Alpine-Kuparuk-Prudhoe

Bay infrastructure or the Umiat road/pipeline. However, a pipeline across the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in disturbance sources within the NPR-A.

Beaufort Sea Development. Offshore development in the Beaufort Sea may require onshore processing facilities and certainly would require onshore pipelines. These facilities would impact Teshekpuk Caribou Herd caribou during the calving and insect-relief seasons and may accumulate with other disturbances for that herd during those seasons. At some point, impacts of these types during those seasons could have population level effects on the Teshekpuk Caribou Herd, although it is not clear that has occurred for the Central Arctic Herd under similar circumstances. If the BLM chooses Alternative B-1 of this plan, it would preclude development along the entire length of the NPR-A coast from Barrow to the Kuupik Corporation lands just west of the Colville River. The economic possibility of development in that portion of the Beaufort would be greatly reduced and the outcome for terrestrial mammals would be less disturbance than what might occur under the other alternatives. Alternatively, if oil is developed in this region of the Beaufort and this plan allows it to come ashore, the distribution system from there to the Trans-Alaska Pipeline System may make smaller oil and gas fields more economical in the northeastern NPR-A. This may provide a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's scenarios.

Commercial Gas Pipelines. Construction of gas pipelines would have short-term effects on wintering caribou if caribou are present during construction. This could affect both the Central Arctic Herd and Teshekpuk Caribou Herd. Once buried, the pipelines would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor and would not accumulate. A much greater impact from these pipelines would be effects from all the gas development that a pipeline would make possible (already analyzed under all alternatives) within the NPR-A and to the east.

Conventional Oil and Gas Development between the Colville and Canning Rivers. Any disturbance of mammals caused by additional development in this area would have additive impacts only if it occurred in areas and time periods separate from existing disturbances. Otherwise, these impacts could accumulate with those of existing disturbance. The area between the Colville and Canning rivers represents much of the range of the Central Arctic Herd. In some winters, this area is also important habitat for some Teshekpuk Caribou Herd caribou. Disturbances in this area during caribou calving season would not accumulate with any similar impacts in the NPR-A because neither of these two herds calves in both areas.

Unconventional Oil and Gas Development between the Colville and Canning Rivers. Cumulative impacts from these activities would be the same as for conventional oil and gas in this area. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on time and place of the impacts.

Proposed Road to Access the Ambler Mining District. If built, this access route would cut across the fall and spring migration path of the Western Arctic Herd and possibly through Western Arctic Herd wintering habitat. If it connects to the Dalton Highway, it would provide road access to the Western Arctic Herd by hunters and recreationists from throughout Alaska's mainland road network. This would create a major new mechanism for disturbance of the Western Arctic Herd and this effect would likely accumulate with disturbances from the NPR-A and areas west and southwest of the NPR-A. Combined, these disturbances could increase mortality and decrease productivity enough to cause a population level impact to the Western Arctic Herd.

Spills and Gas Releases

The oil industry is required to have oil spill response and clean-up capabilities, and small spills on lands or waters in the NPR-A or in existing or future North Slope oil fields are expected to be contained and cleaned up before substantial mammal and habitat loss can occur. In addition to mortality through direct contact with oil, some mortality could result through ingestion of contaminants in food and water from the cumulative effects of the numerous small spills expected from the operation of any oil field. Indirect impacts to mammals through habitat loss would likely be negligible due to the small number of acres affected.

The spills associated with reasonably foreseeable future projects could affect terrestrial mammals on the North Slope. Cumulative effects would depend on the number, size, location, and timing of spills, the type and effectiveness of the oil spill response, and the species and population of terrestrial mammals exposed to the spill. Potential oil spills from both offshore and onshore oil activities would be likely to have a small effect on terrestrial mammals because comparatively low numbers of animals would be expected to be disturbed or contaminated, or to ingest contaminated food sources and die as a result. Spills would have mostly sublethal effects on terrestrial mammals and would impact only a very minor percentage of the available habitat. The greatest potential for impact to terrestrial mammals would be through disturbance impacts during response, cleanup, and rehabilitation.

The amount of oil produced on the North Slope from 2012-2100 (88 years) under the reasonably foreseeable future scenario is less than that produced from 1977 to now (34 years), so the average annual amount would be much less than in the past. As oil production slows, coupled with improvement in spill prevention, control technologies and training, the potential for effects to mammals should decline over time. This potential downward trend could be countered, however, if an aging pipeline system led to an increase in pipeline leaks.

Any accidental gas releases that occur in the future would affect only those individuals that are nearby at the time of the release. Any impacts to mammal populations would likely be negligible and would not accumulate.

Abandonment

Abandoned gravel pads and roads could provide some benefits as insect-relief sites for caribou, and provide special habitat for burrowing species such as foxes. The ultimate fate of the gravel pads and roads would not be known until closer to the end of the production field life. Permitting agencies could require that gravel be removed, in part or total, and the tundra revegetated. If other uses are determined by the permitting agencies to be preferable, the agencies could allow the permittee to leave the gravel pads in place, either revegetated or not revegetated. Removed gravel either would be disposed of or reused for another development.

Abandonment of airstrips could occur in conjunction with abandonment of pads. The gravel airstrips would be managed in a similar manner, depending on the decisions made by land managers and permitting agencies at the time of abandonment. Gravel airstrips would either be removed and the tundra revegetated, the gravel revegetated but otherwise left in place, or left in place and maintained for public use.

Summer road and air traffic generated by abandonment and reclamation activities could cause disturbance, displacement, and mortality to caribou and other mammals. These impacts would be similar to and at the same levels as those caused by traffic during construction, and greater than those during normal field operations. If pads, roads, and airstrips were revegetated without removing the gravel, the habitat would not return to its current utility in the foreseeable future. If gravel was removed, habitat similar to that currently existing in the area could be created and used by mammals, though it would still take decades for recovery and the precise mix of habitat types would likely not be the same as what prevailed at the time of disturbance. The effects of habitat loss would accumulate, as described above, to the extent that habitats were not, or could not be, restored to their original condition.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Impacts from ice road construction would occur on 231,995 to 456,683 acres during the life of the plan, while impacts from ice pads and ice airstrips would occur on another 1,483 to 2,856 acres; these impacts to habitat would be short-term and would not accumulate. Long-term impacts to habitat from seismic surveys in the NPR-A would occur on approximately 1,500 to 2,700 acres under the five alternatives. Development in the NPR-A under Alternatives A, B-1, B-2, C and D, respectively, could directly impact approximately 9,900, 7,500, 8,400, 15,300, and 16,330 acres, and indirectly impact 29,300, 20,730, 23,600, 40,500, and 43,570 acres of vegetation (mammal habitat)(Table 4-14 in Volume 2). These impacts would be long-term and would accumulate. Total, long-term, direct and indirect impacts to vegetation from exploration and development combined would occur on 0.12 percent (Alternative B-1) to 0.26 percent (Alternative D) of the NPR-A. These habitat losses would account for up to 53 percent of the total habitat projected to be lost due to development on the North Slope from now until 2100.

Functional loss of habitat as a result of displacement due to disturbances, could involve a much greater area. Given that the area most likely to be developed for oil under the action alternatives (economic zones 110 and 120, section 4.2.1.2. “Discovery and Development,” Volume 2) includes the most important calving and insect-relief habitat for Teshekpuk Caribou Herd caribou, impacts to caribou, other mammals, and their habitats could be much greater than predicted based solely on amount of area disturbed. Similarly, gas development could overlap with the calving grounds of the WAH under Alternatives C and D. Because of the importance of these areas, Lease Stipulations/Best Management Practices K-5, K-6, K-9, K-10 and K-11 were developed to provide special restricted surface occupancy protection to caribou habitat, though not all of these protections would apply to Alternative D. Still, caribou and other wildlife would be exposed to oil and gas disturbance in their calving, summer, and potentially winter, ranges. Depending on the types and locations of facilities, impacts to caribou and other mammals could accumulate, especially where species are concentrated such as calving grounds and insect relief areas, and could affect the long-term health of the local population.

The effects to caribou and other mammals from oil and gas development would be least under Alternative B-1, because much of this area would not be available for leasing under this alternative. The effects would be similar under Alternative B-2 and greatest under Alternative D, in which the entire area would be open to leasing with fewer mitigations than under other alternatives. Offshore development associated with leases in the Chukchi and Beaufort seas could impact relatively small areas along the coast for staging and storage of materials, and could impact a swath across the entire mid-section of the NPR-A if a road and pipeline is built from the Chukchi Sea to the Trans-Alaska Pipeline System.

Impacts to vegetation (mammal habitat) and direct disturbance of mammals on the North Slope from future oil and gas exploration and development are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past and present oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of habitat impacted by all oil and gas development, and would be additive in nature for the most part. However, depending on oil prices and where and how much oil is ultimately developed in the NPR-A and offshore, there could be synergistic effects on acreage of habitat affected and levels of disturbance to mammals in the NPR-A. This would occur if a discovery in the Chukchi or Beaufort offshore, and the subsequent transportation system (pipelines) would make economic the development of additional oil or gas fields in the northern part of the NPR-A which would not otherwise have been economically developable. Such a scenario could result in additional development in an area that is important insect relief habitat for the Teshekpuk Caribou Herd, and could also increase the probability of development in the Teshekpuk Caribou Herd calving area.

Similarly, development in the northern portion of the NPR-A could have a synergistic effect on terrestrial mammals in the Colville River delta (including Central Arctic Herd caribou), either by providing economic incentive for increased oil/gas development in the latter, or by the need for increased infrastructure or air or ground traffic in the delta to transport oil or gas, or supplies and equipment, to or from the NPR-A. In addition to these other areas, the potential exists for development of production facilities or a staging base on private land at Cape Halkett at the northeastern tip of the NPR-A. These private lands do not have the requirement for a three-quarter- or one-mile buffer along the coast. Development here would potentially impact caribou during the insect season in a manner that would be additive, or perhaps synergistic, to effects from development on adjacent BLM-managed lands. On the other hand, implementation of Alternative B-1 would likely preclude development in the Beaufort offshore because the restriction on the NPR-A would make it much more difficult to transport Beaufort oil or gas to market. This would represent a countervailing effect to total development in the NPR-A.

Synergism affecting primarily the Teshekpuk Caribou Herd through effects in insect relief habitat, but potentially other mammal species as well, could similarly result if development north of Teshekpuk Lake resulted in offshore development being more economically feasible. Such offshore development would likely result in additional habitat impacts from developments built onshore in support of the activities offshore. This would most likely affect the Beaufort Sea coastal portions of the NPR-A. This scenario is not possible under Alternative B-1, because none of the Beaufort Sea coastal area in the NPR-A would be available for lease or for new non-subsistence permanent infrastructure. Under Alternative B-2, there are stretches of coastline both east and west of Teshekpuk Lake that would be unavailable for leasing but would allow the passage of infrastructure from offshore development. For Alternative B-2, impacts to caribou would be similar to, but possibly slightly greater than, those under Alternative B-1. Synergistic impacts to caribou would be most likely under Alternative D because no areas would be unavailable for leasing under that alternative and there are fewer development restrictions. It would be less likely under Alternative A because of development constraints, and less yet under Alternative C because of development constraints and some coastal lands being unavailable for lease and in which new non-subsistence infrastructure would not be allowed.

Overall, the precise impact to caribou cannot be stated regarding development north of Teshekpuk Lake of oil and gas resources existing in currently unknown quantities and distribution. An estimate of acres of habitat alteration can be made (as above) and it is acknowledged that displacement of caribou around that infrastructure is likely to further increase the effective loss of habitat. If gravel placement occurs primarily on the better-drained soils, which are more important to foraging caribou, then the effects on caribou of this habitat loss would be disproportionate to percent of total area developed. In addition, climate change may result in a calving shift to the north as a result of earlier spring melt, creating additive, or perhaps even synergistic, effects to those of development north of the lake. Alternatively, vegetation change resulting from climate change may have a countervailing effect to disproportionate development of caribou foraging habitat by causing an increase in better-drained soils and associated habitats. As stated above, a consequence of all these potential impacts may be decreased productivity, which if great enough would result in a negative population level effect to the Teshekpuk Caribou Herd.

Conclusion

Cumulative oil development in the Prudhoe Bay-Kuparuk area encompasses more than 500 square miles, and hundreds of miles of gravel roads cross a large portion of the Central Arctic Herd calving range. By 2001, more than 17,000 acres of habitat had been destroyed or altered where roads, gravel pads, gravel quarries, pipelines, pump stations, and other facilities had been constructed on the North Slope. An additional 13,750 acres are expected to be directly affected by gravel footprint and material sites from reasonably foreseeable development in the NPR-A. Another 12,400 acres across the North Slope could be affected this way by construction of infrastructure associated with an Umiat road, offshore development, commercial gas pipelines, additional development of conventional oil and gas on state and private lands, and development of unconventional oil and gas on those same lands over the next 88 years (through 2100). All of this acreage represents habitat for mammals to one extent or another.

Cumulative effects on caribou distribution and abundance are likely to be long term, lasting as long as the life of the oil and gas fields. Any reduction in calving and summer habitat use by cows and calves as a result of future onshore development in support of onshore or offshore leasing would represent a functional loss of habitat that accumulates and could result in long-term effects on the caribou herds' productivity and abundance. These impacts would likely be greatest under Alternative D and lowest under Alternative B-1. However, this potential effect might not be measurable given the great natural variability in a caribou population's productivity. The effects of oil and gas activities in the NPR-A would be greatest on those herds that use the NPR-A (large numbers of Teshekpuk Caribou Herd and Western Arctic Herd and smaller numbers of Central Arctic Herd caribou). If climate change over the next several decades were to result in widespread changes in vegetation composition and insect abundance, disturbance effects of oil and gas activities to terrestrial mammals could be exacerbated, and could extend beyond the life of the oil and gas fields. If these cumulative effects were to result in reductions in caribou populations, there could also be a reduction in the abundance of predators such as wolves, bears, and wolverines.

These impacts to caribou and perhaps their mammalian predators from activities in the NPR-A are expected to be additive to those from other activities except in the following potential cases where synergism is likely. If large discoveries are made in the Chukchi or Beaufort offshore, it could make additional developments in the northern NPR-A more economically feasible resulting in even more habitat and disturbance impacts in the NPR-A than assumed in section 4.2.1.2. "Resource Potential and Petroleum-related Activities" (Volume 2), especially in areas critical for insect-relief by caribou. This possibility is most likely under Alternative D and least likely under Alternative B-1.

Other impacts that could prove to be synergistic rather than additive are the combined effects of vegetation change (from both human activities and climate change) and climate change induced weather patterns on the productivity of all mammalian populations; vegetation change, climate change induced weather patterns, increased insect activity and year-round development effects on the productivity of caribou populations; and of predation, oil development and climate change on muskoxen. Mammalian populations have inherent levels of resilience, through behavioral flexibility and movement, to change in different factors affecting survival and productivity. Development of oil and gas in the NPR-A, alone or in combination with similar development elsewhere on the North Slope or offshore, could result in a decrease in the level of resilience. For some species, the magnitude of decrease may be adequate to result in negative population level responses.

4.8.7.10 Marine Mammals

Marine mammals occur in the Beaufort and Chukchi Seas as described in Chapter 3. These include bowhead, beluga and gray whales, ice seals, polar bear, and walrus. Other species, such as harbor porpoise, narwhals, killer whales, minke whales, humpback, and fin whales, appear to be expanding their ranges north into the Chukchi and Beaufort seas during the summer, open water months.

This section discusses the cumulative effects on nonspecial status marine mammal species from North Slope onshore and offshore oil and gas leasing and development activities. Current and proposed development activities could also affect other marine mammals whose ranges are located within oil transportation routes in the Bering Sea and Gulf of Alaska, in the latter case, originating from the Trans-Alaska Pipeline System terminal in Valdez. The potential direct and cumulative effects of marine mammal populations located along these tanker routes are discussed elsewhere (USDOI BLM 1998b; USDOI Minerals Management Service 2002). The evaluations of potential impacts presented in the documents referenced above suggest that routine operations should have minimal impacts on marine mammals and that the most significant threat to marine mammals is an unlikely large oil spill that contacts marine mammals or their habitat. This assessment is likely true, however, there are currently no available quantitative approaches for assessing cumulative impacts to marine mammals in the Beaufort and Chukchi seas. A large oil spill could have a major impact on marine mammals. Cumulative effects from the multitude of other human activities in combination with climate change may also have substantial impacts.

While most of the effects of the NPR-A activities addressed in this document are expected to accumulate in the northern Chukchi and Beaufort Seas, most tanker traffic associated with the Trans-Alaska Pipeline System occurs within the Gulf of Alaska and Pacific Ocean. Any potential impacts from that tanker traffic would most likely affect different marine mammal individuals or populations than those occurring in the NPR-A area. Impacts from tanker traffic associated with the Trans-Alaska Pipeline System are, therefore, not expected to measurably accumulate with North Slope operations, so are not included in the following cumulative effects discussion.

This section describes the incremental effects of the IAP/EIS alternatives combined with the past, present, and reasonably foreseeable actions that will also act upon the marine mammal resources. For impacts to accumulate they must persist through time, either through the extent of their temporal distribution, or because the magnitude (intensity and spatial scale) is sufficient to affect populations for long after the disturbance has ceased or some combination of both.

The geographic scale of potential past, present, and reasonably foreseeable future impacts on marine mammals is species and population dependent. Many species, such as beluga whales, undergo high-latitude long distance migrations and cumulative effects would accrue from activities occurring within the Beaufort, Chukchi and Bering Sea areas. In the case of gray whales, exposure to cumulative effects reaches to Mexican waters. Similarly some of the less common species (e.g., harbor porpoise, killer whales) may also be affected by activities occurring from the Beaufort to the Bering Sea. With the exception of commercial whaling (a past activity that profoundly impacted the eastern North Pacific gray whale population), the following discussion focusses on past, present, and reasonably foreseeable future actions in Arctic waters.

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Commercial Whaling. Pacific gray whales were severely and repeatedly depleted across their range during intense commercial whaling over the last 150 years. Nonetheless, researchers suggest that eastern Pacific gray whales have recovered to their pre-commercial whaling population level and their abundance is currently restrained by the carrying capacity of their range (reviewed in Allen and Angliss 2010).

Commercial Shipping. As climate change continues to lessen the amount of sea ice in the Arctic during the summer, there is more and more interest in transiting through the Northwest Passage through Canada or across the Northern Sea Route off of Russia. This is more likely in the future but has already begun through the Northern Sea Route. Russia has begun moving transport vessel through the Bering Strait. This increase of vessels in the Bering and Chukchi seas increase the potential for ship strikes to marine mammals and the possibility of contamination from discharges from vessels or oil spills.

Contaminants. Many man-made contaminants are transported into the Arctic through the atmosphere and sea currents. Many of these have already found their way into marine mammal tissues, although to the level that is thought to causing health issues. Some of the man-made contaminants have been "locked-up" in ice, snow, or permafrost. As climate change causes ice, snow, and permafrost to melt or thaw more quickly and extensively and coastal erosion increases, some of the chemicals previously isolated in ice and permafrost may become a source of contamination to species living in the Arctic. Naturally occurring contaminants (i.e., some heavy metals) are also present in the Arctic. Effects of contaminants will vary by species due to species specific traits such as trophic foraging level, reproductive physiology, life span, and other factors. Top trophic foragers have a higher chance of being affected by contaminants than lower trophic foragers due to biomagnification. Population level effects from contaminants could be realized if reproductive capacities are disrupted or a large proportion of a population succumbs to toxic effects (AMAP 2002), although there is no indication this will be an imminent problem for marine mammals in the Beaufort or Chukchi seas.

Hard Rock Mining. One operating hard rock mine, the Red Dog Mine, currently exists in the U.S. Arctic along the Chukchi Sea southeast of Point Hope and south of the NPR-A. The mine is primarily removing zinc and lead. While the mining activities take place onshore, material is moved south by marine vessels during the open water months. Increased levels of heavy metals could occur near operations. Aircraft also provide support for the mining operations. These activities could contribute to potential cumulative effects on marine mammals primarily through disturbance caused by sounds produced from the operations deflecting animals away from sound sources and interfering with communication as described in section 4.3.10 (Volume 2).

Distant Early Warning-Line sites/Long- and short-range Radar Sites. The military continues to operate some radar sites across the Arctic and subarctic. Some of these sites are unmanned although several still have a small group of on-site personnel. Many of the old Distant Early Warning-Line sites have been abandoned with some efforts at rehabilitation and restoration. These restoration and rehabilitation activities, which involve the barging of equipment, construction materials, and some hazardous wastes, may have caused some noise disturbance effects in the past, and could, through the future introduction of noise into the marine environment, continue to contribute to the cumulative effects to marine mammals.

Tourism and Recreation. Recreation and tourism activities typically involve non-residents of the North Slope. Cruise ships, accommodating several hundred passengers, now transit through the Northwest Passage several times a year. Smaller craft, often involving adventurers or sailors, also transit the Northwest Passage. Marine and coastal vessel and air traffic, supporting onshore tourism and recreation, could contribute to potential cumulative effects through the disturbance of marine mammals.

Disturbance could occur through the introduction of anthropogenic sounds into the water or through the discharges or oil/fuel spills.

Scientific Research. Climate change has increased the interest of the public in the Arctic for a variety of reasons. There has been a concurrent increase in interest among policy makers and scientists to better understand the arctic environment and the effects of the ongoing changes. Along with a relatively small number of long-term studies that have been conducted over many years, an increasing number of scientific research programs are taking place across the North Slope and in nearshore and offshore areas of the Beaufort and Chukchi seas, including within and adjacent to the NPR-A. These activities involve vessel, air, and over-ice support, which may contribute to cumulative effects through disturbance of marine mammals.

Most shore-based studies occur during the summer when marine mammals are more likely to be present near the NPR-A. Many of those studies use aircraft to conduct surveys or establish or resupply field camps. The presence of camps or sounds from aircraft could impact marine mammals by causing disturbance or displacement, primarily to marine mammals near the coast. Some of these studies involve large ocean going vessels and, in some cases, icebreakers. Studies may also include seismic airgun arrays to provide a better scientific understanding of the geology of the area. Smaller vessel and aircraft may be used to support these offshore studies. Sounds from vessels and aircraft may disturb or deflect marine mammals from traditionally used areas. Ship strikes from research vessels could also contribute to cumulative effects on marine mammals.

Subsistence. Subsistence activities occur across the NPR-A and in coastal and offshore areas adjacent to the NPR-A. Subsistence hunting of marine mammals is protected by a Marine Mammal Protection Act requirement that other activities not have an unmitigatable effect on the availability of marine mammals for subsistence uses. Subsistence hunters primarily use boats and snowmobiles for access to hunting areas. These hunting activities contribute some anthropogenic sounds into the marine environment, and direct mortality of harvested animals.

Oil and Gas Exploration and Development Activities

Section 4.8.3 describes the North Slope oil and gas activities that have or are contributing to the cumulative effects to marine mammals. In addition, there are activities that are occurring outside the U.S. borders that may be affecting marine mammals. This is especially true since most of the marine mammals are highly migratory and move between U.S., Canadian, and Russian waters.

Oil and gas exploration is occurring in the Canadian Beaufort Sea in shallow and deeper water habitats. Seismic surveys, both 2-D and 3-D occur during the open water months when marine mammals may be present. Sounds from airgun arrays for seismic surveys and accompanying ship sounds may cause disturbance, deflection, or interference with marine mammal communication and echolocation. This is a major concern as spring and summer months are important for feeding, calving, pupping, rearing young, and molting. Exploratory drilling in shallow water habitats typically occurs during the winter when fewer marine mammals are present but mobilization and demobilization of equipment occurs during the open water months. Thus additional effects from sounds associated with mobilization and demobilization may occur. Drilling in deeper water habitats may more likely occur during the summer open water months.

It is not clear what oil and gas activities may be occurring in the Russian Chukchi Sea. If seismic surveys or exploratory drilling are occurring there, marine mammals that also utilize waters adjacent to the NPR-A may be exposed to a high level of anthropogenic sounds and possible ship strikes in that part of their ranges.

Unfortunately, there are currently no well-established quantitative analytical techniques to assess cumulative effects from multiple stressors. Therefore, it is difficult to determine whether the past and present activities, have had cumulative effects to marine mammals.

Summary of Past and Present Effects and Their Accumulation

The Arctic is often considered to be a pristine environment and relative to other areas, much of the Arctic is pristine. There have long been substantial human activities and impacts in the Arctic. For gray whales, the most dramatic population level impacts were associated with commercial whaling that occurred from the mid-19th through the early 20th centuries. More recently, climate change and increasing human activities (particularly with regard to oil and gas activities) may be having as yet uncertain, but, possibly, substantial impacts. Limited data preclude the quantitative assessment of cumulative effects for most marine mammal populations. Other than gray whales, abundance estimates are unreliable and population trends are poorly understood or completely lacking for non-special status marine mammals in the Beaufort and Chukchi seas (Allen and Angliss 2011). Understanding and differentiating population level effects from climate change impacts, oil and gas activities, or other factors is extremely difficult. Some information is available on how individual animals respond to oil and gas activities but the observations are short term and provide little usable data for longer-term or population-level effects.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

In light of credible modeled predictions that the extent of summer sea ice will continue to decrease and reach near zero coverage within only a few decades (Wang and Overland 2009), commercial shipping throughout the Arctic is likely to increase in the future (Arctic Council 2009). Larger numbers of vessels in the Beaufort and Chukchi seas will put more sound into the water, potentially causing more marine mammals to deflect or be disturbed, and masking sounds the animals use to communicate or to sense their environment. Increased traffic would increase the risk of ship strikes and the potential for adverse impacts associated with bilge discharge or spilled fuel.

Although commercial harvest of fish resources in the Arctic Management Area is prohibited until there is sufficient information available to "support sustainable management of a commercial fishery" (NPFMC 2009), commercial fishing could increase in the future Commercial fisheries on the North Slope are currently generally small coastal operations that likely affect only a small number of marine mammals. If large commercially exploitable stocks of fish are found in the region, increased numbers of fishing vessels could expand northward into Arctic waters. Commercial fisheries would potentially compete with seals and beluga whales for prey species, and seals and whales could suffer increased mortality from entanglement in fishing nets and other gear. Marine mammals may also be displaced from preferred feeding habitats by noise and visual disturbances caused by fishing activities.

As public awareness of the Arctic increases, there will likely also be a continued increase in tourism and science. Impacts associated with these activities will be similar to those described for fishing and commercial shipping.

Oil and Gas Exploration and Development Activities

It is reasonable to expect that oil and gas leasing and exploration will continue in the Beaufort and Chukchi Seas and in adjacent onshore areas and that development will occur as well. Such activities will increase the amount of anthropogenic sounds in water, increasing the potential for the deflection or disturbance of marine mammals, and the masking of their sounds. Exploration and development activities will increase the potential for ship strikes, and increase the possibility of an oil spill or other harmful discharge. The activities that will likely have the largest short-term impact will be from noise associated with seismic surveys and large ships. The longer-term impacts will be from the increase in noise in the ocean that may mask marine mammals' ability to communicate or sense the ocean around them. Large oil spills could cause some direct mortality, indirect effects, such as reduced reproduction and survival, or habitat alteration for individuals but not to a level that would result in population or stock level effects.

Seismic Activities and Exploration. Seismic activities are expected to continue in both the Chukchi and Beaufort seas (USDOI Minerals Management Service 2007). Previous analyses conducted for lease sales in these areas and to permit seismic activity indicated that while impacts were expected they were not expected to cause population level impacts or long-term area abandonment (USDOI Minerals Management Service 2007a and 2006b, USDOI BOEM 2011). It is unclear whether future impacts from seismic surveys and exploration could have significant affects to marine mammal populations.

Oil and Gas Development and Production. Future activity could occur in the Beaufort Sea from Barrow to Flaxman Island, and possibly to the Canadian border or in Canadian waters. Onshore potential future developments, including at Alpine satellite sites, Point Thomson, and the possible construction of commercial gas pipelines are likely to result in additional vessel and aircraft traffic. Vessel traffic would be intermittent with occasional large sea-lifts. Aircraft traffic is expected to occur over land or in close proximity to the coast.

Activity in the Chukchi would occur offshore of northwestern Alaska from Point Hope to Barrow (USDOI Minerals Management Service 2006). Beaufort Sea development activity is expected to occur mostly near shore, and would entail methods and structures similar to those currently in use (gravel islands or bottom-founded structures, horizontal drilling, buried pipelines, and an emphasis on construction during winter). Chukchi Sea development is expected to be offshore. It is not yet clear how oil might be produced at the offshore prospects. It is likely the oil would be transported to shore via a pipeline that connected across the NPR-A to the Trans-

Alaska Pipeline System. The potential effects of development in these areas is described in the EIS documents for Chukchi Sea Lease Sale 193 (USDOI Minerals Management Service 2007a) and Beaufort Sea Lease Sales 186, 195, and 202 (USDOI Minerals Management Service 2003), as well as the subsequent Environmental Assessments for the 195 and 202 sales (USDOI Minerals Management Service 2004 and 2006), the Final Programmatic EIS for the Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017 (USDOI BOEM 2012), and Draft Environmental Impact Statement for Effects of Oil and Gas Activities in the Arctic (NMFS 2011).

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Contribution of effects from NPR-A to the overall cumulative effects to non-special status marine mammals will likely be relatively small. Climate change, offshore oil and gas exploration, development and production, and commercial shipping and fishing could have large effects on marine mammals in the future. Those effects will be from anthropogenic sounds, ship strikes, and possible discharges, including spilled oil. The allowance of new non-subsistence infrastructure, including that associated with offshore development, in coastal areas such as Dease Inlet/Admiralty Bay, Kasegaluk Lagoon, Wainwright Inlet/Kuk River, and Peard Bay under most alternatives (except Alternative B-1) could facilitate offshore development and impacts on NPR-A coastal areas, Alternative B-1, therefore, has the greatest potential to minimize potential impacts from offshore development and result in the smallest contribution of the alternatives to cumulative effects. Other human activities, such as tourism, activities at local communities and science will likely have smaller effects, perhaps about the same level as activities within the NPR-A.

Conclusion

Commercial whaling caused the greatest impact to the populations of large baleen whales in the past 150 years. In addition to noise and disturbance from existing oil development, marine mammals could be affected by future offshore development in the Beaufort and Chukchi seas, increased shipping associated with both onshore and offshore oil and gas development and from North Slope community development, and from any expansion of commercial fishing activities. Subsistence hunting of marine mammals by Alaska Natives is not likely to affect these species at the population level. Disturbance could result in temporary displacement from preferred feeding habitats. An oil spill could affect marine mammals in offshore or coastal areas, with the impacts to marine mammals depending on the location and amount of oil spilled and the time of year. The effects of future habitat alteration associated with gravel island construction, pipelines, or other structures related to oil development would likely be minor. The presence of small amounts of hazardous materials, including hydrocarbons and insecticides, would likely have minor effects on marine mammals. Climate change may result in more ship traffic in Alaskan arctic waters over a longer season, the expansion of commercial fisheries into the Chukchi and Beaufort Seas, altered prey fields or availability, and displacement and distributional changes, if not population changes, among marine mammals.

The possible marine activities associated with oil and gas and other activities within the NPR-A are relatively small compared to the many other large changes that are occurring in the Arctic Ocean. Therefore, activities associated with NPR-A will likely have only a small contribution to cumulative effects to marine mammals in the Beaufort and Chukchi seas.

Climate change, including ocean acidification, commercial shipping and offshore industrial development are likely to have the greatest influence on marine mammal populations in and adjacent to the NPR-A. Species resilience and resistance to the changes associated with climate change as well as feedback and interactions remain highly uncertain.

4.8.7.11 Special Status Species

The following discussion of impacts is divided into four sections that discuss Special Status Species of plants, birds, terrestrial mammals, and marine mammals.

Special Status Species of Plants

Development would be unlikely to affect the existence of any plant species or any plant community at scales larger than local road effects. However, if development facilities were constructed in an area containing a population of a BLM sensitive plant species (by definition rare), the impacts to that population and thus the species could be severe. These impacts could be greatly mitigated by surveying for sensitive plants early in the planning stage in areas proposed for development, and then avoiding any populations of sensitive plant species.

The types and sources of impacts to sensitive plant species would be the same as for vegetation in general. The probability of occurrence, though, would be substantially less than for other plant species because of the rarity of sensitive plant species.

Due to their rarity and the relative ease of mitigating adverse effects from anthropogenic activities, it is unlikely that anthropogenic impacts to any sensitive plant species would accumulate on BLM managed lands in the NPR-A. These species do not enjoy the same level of protection on state or private (Native corporation) lands, however, so some potential for partial or complete loss of populations following new development remains and may accumulate on state and private lands. This potential is still influenced by the plants' rarity, making it unlikely that impacts to one species would accumulate due to disturbance in two or more areas occupied by one of these species.

Rare plants are often rare because their habitat requirements are met in limited (both in number and geographic extent) areas. This situation is often related to changing habitats during past periods of substantial climate change. Future climate change may limit even further the suitable habitat for some of these species, and this effect may accumulate with any adverse impacts of oil or gas development. The two combined may have synergistic impacts on the probability for continued existence on the North Slope of some of these species.

Special Status Species of Birds

This section discusses the potential cumulative effects to Special Status bird species (yellow-billed loon, spectacled eider, Steller's eider, Kittlitz's murrelet, red knot, short-eared owl and golden eagle) that could result from management actions in the NPR-A. The geographic extent of this analysis includes the North Slope and the migratory and wintering range of the species discussed. Reasonably foreseeable impacts are considered from the present until 2100. The species addressed in this section are migratory and do not occur in the NPR-A during winter. The majority of the activities that could potentially contribute to the cumulative effects to Special Status Species in the NPR-A would result from oil and gas exploration and development that may occur in addition to the proposed action of this plan. In addition, any analysis of cumulative effects to Special Status Species must include effects during migration and at wintering areas, where impacts could be independent of activities in the NPR-A. Because Special Status Species populations can show substantial changes among years, it is often difficult to determine if effects are accumulating at the population level, or merely reflect short-term shifts in population numbers. It is expected that any effects from cumulative actions to populations of red knot, short-eared owl and golden eagle would not be discernible due to their unknown and likely very low population levels in the NPR-A and so are not discussed in this section. Kittlitz's murrelet have been seen in very low numbers in the nearshore waters of the Chukchi Sea within the NPR-A but they have not been found on land and would not be expected to as their habitat requirements for nesting are not found in the NPR-A. Kittlitz's murrelet is only referenced in this section from the perspective of offshore habitat loss or disturbance. Please see section 3.3.8 (Volume 1) for a detailed description Kittlitz's murrelet, their habitats, migration routes and wintering areas.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Activities that occur on the North Slope and are not directly related to oil and gas development and contribute to the cumulative effects to Special Status Species in the planning area include subsistence activities (including hunting, fishing, berry picking etc.), recreational use, activities associated with scientific surveys and research camps, village expansion, cleanup of old oil and gas exploration sites, and activities associated with government actions (e.g., cleanup of abandoned well sites). These activities could affect tundra nesting birds by causing: 1) temporary or permanent habitat loss; 2) various types of disturbance related to equipment and facility noise, vehicular and air traffic, and pedestrian activities; 3) increased predation; and 4) mortality resulting from collisions with vehicles or structures, or exposure to contaminants, including spills of hazardous materials. Activities that would likely cause the greatest effects to Special Status Species or their habitats are those that lead to habitat loss and associated increases in human caused disturbances.

Distant Early Warning-Line sites and other military facilities, villages, public roads, airstrips, landfills, and other non-oil and gas infrastructure have caused the loss of habitat for some Special Status Species (specifically for spectacled and Steller's eider) and increased levels of disturbance within the NPR-A and within the six North Slope villages considered in this cumulative effects analysis. Impacts from military Distant Early Warning-Line stations include habitat loss for some species resulting from areas where gravel and sand have been removed along the coast and placed on tundra in order to develop roads, airfields and support buildings causing the loss of habitat for spectacled and Steller's eiders. Habitat loss due to the placement of gravel on the tundra persists today and these sites also provide a potential starting point for recreational and sport hunting trips. It is very likely that the sand and gravel removed from the coast has been replaced via long-shore transport and/or river flow and that habitat has been restored to its original condition. Hazardous material or debris and structure removal has occurred at many of the Distant Early Warning-Line stations resulting in a reduction in contamination of areas potentially used by Special Status Species. Clean-up activities at these and other sites in the NPR-A involves the use of fixed-wing aircraft or helicopters, to access remote areas, which can disturb birds.

Since the early 1900s, six villages have been established or reestablished in the western North Slope and these villages have continued to grow in area and in population resulting in habitat loss and increased human disturbance. The footprint of the existing communities considered in the cumulative effects analysis of this document are expected to double in size by 2050 (see section 4.8.2) if onshore and offshore oil and gas development increases as predicted by Thomas et al. (2009). This increase will likely lead to an increase in the filling of wetlands and loss of natural habitats, increase in size of landfills and an increase in human activities that may cause disturbance to Special Status Species. Areas around these villages are known to host many different species of birds and the effects to Special Status Species (especially to spectacled and Steller's eiders) would depend on into what habitats the expansion actually occurs. Impacts from activities associated with military uses and village expansion would likely be localized, would be expected to persist, may accumulate and would likely have a greater negative effect if habitat loss and/or human disturbance occur in areas where large numbers of eiders are breeding. Private and commercial air traffic occurring in the NPR-A likely impacts Special Status Species very little as that type of traffic is usually at elevations above that which most often causes disturbance. Aerial surveys for wildlife in the planning area could include both fixed-wing aircraft and helicopter surveys. Low-level fixed-wing aerial surveys would probably have little effect on Special Status Species due to the short amount of time during which aircraft would be in a particular area. Wildlife telemetry studies involving the use of helicopters could cause greater disturbance to Special Status Species due to the take-offs and landings required for deploying ground personnel for attachment of transmitters. The effects to Special Status Species from these activities could range from temporary displacement from preferred feeding habitats to nest abandonment and loss of production for the breeding season. Impacts would likely be localized and the effects would not be expected to persist or accumulate.

Various types of disturbances affect tundra-nesting Special Status Species near seasonal camps. Noise and ground activities disturb feeding, nesting, molting and brood-rearing birds, causing temporary or permanent displacement from feeding or nesting areas potentially affecting energy budgets and productivity. Aircraft activity to mobilize and re-supply summer camps could disturb Special Status Species along continually used flight corridors and near airstrips during take-offs and landings. Special Status Species could also suffer mortality due to collisions with aircraft. Nesting birds near seasonal camps could suffer mortality or egg loss due to predators attracted to anthropogenic sources of food at camps. Effects of this type of visual and noise disturbance could range from temporary displacement from preferred habitats to nest abandonment to death. Impacts would likely be localized and the effects would not be expected to persist or accumulate. Although pedestrian traffic has been shown to be particularly disruptive to some waterfowl and raptors (Roseneau et al. 1981, Ritchie 1987, Johnson et al. 2003b), some eiders may have acclimated to predictable daily activities of camp personnel. Ward et al. (1999) studied brant response to fixed-wing and rotary-wing aircraft and reported brant response to aircraft at a lateral distance to 3 miles, although the majority of birds responded to aircraft that were within a lateral distance of ½ mile or less. The greatest response to aircraft altitude occurred between 1,000 and 2,500 feet. Nesting eiders may not be as sensitive to aircraft as molting or staging waterfowl. No significant changes in behavior were noted for eiders adjacent to a construction site in the Colville River Delta and subject to repeated fixed and rotary winged aircraft (Johnson et al. 2006). Although there is limited information on historic numbers of eiders and other special status bird species found in these non-oil and gas developed areas, development, loss of habitat, and disturbance, coupled with hunting pressure at a "shooting station" near Barrow, and other recreational and subsistence hunting near other villages, has caused the loss of Special Status Species and their habitats that has accumulated.

Aside from direct mortality due to subsistence harvest, the accumulation of lead shot in spectacled eiders foraging habitat in the Y-K Delta has likely been responsible for loss of eiders and likely effects nest success (Flint et al. 1997, Grand et al. 1998, Flint et al. 2000). This may be the most significant direct anthropogenic impact that has impacted Alaska's population of spectacled eiders.

Oil and Gas Exploration Activities

The primary factor associated with oil and gas exploration activities that would affect special status bird species in the NPR-A is loss of habitat. Most seismic surveys and exploration drilling activities occur during the winter months when these birds are not present in the planning area consequently it is expected that direct effects from disturbance is not a factor.

Land based seismic surveys have been conducted over most of the North Slope since 1940 and vegetation has been disturbed to varying degrees depending on a variety of factors related to the type of equipment used and the winter travel restrictions that have been in place. Refer to section 4.8.7.5 for information on cumulative effects on vegetation from seismic surveys. Use of newer technologies, including vehicles that apply less pressure to the ground and restricting travel to periods when there is adequate snow and frost cover to protect vegetation, has reduced the level of impacts to vegetation. Seismic activities may have indirectly affected Special Status Species during the summer breeding season via habitat disturbance as construction of these ice-roads, snow trails and ice-pads temporarily alter tundra habitats by compressing standing-dead vegetation or delaying the growth and development of vegetation, due to protracted ice melt. It is not known if these impacts to vegetation, thus habitat, persist for more than a few years and if those impacts accumulate. Effects to birds from the previous use of airguns for boat-based seismic work in Teshekpuk Lake were not documented, however it is reasonable to assume that if waterfowl were present in the area of the seismic work then they may have been displaced from preferred feeding habitats by either the boat traffic or the seismic noise while surveys were being conducted. Spectacled eider densities are medium high to high northeast of Teshekpuk Lake, and Steller's eiders have been seen nesting near Teshekpuk Lake. Eiders near the shoreline could have been temporarily or permanently displaced from nests by boat disturbance, however, these surveys have only occurred a few times in the past, and it is unlikely that effects to eiders have accumulated.

Other sources of habitat loss include exploration sites with gravel pads, disturbed areas around these pads, exploration airstrips, and gravel exploration roads. Based on a report by the National Research Council (2003), in 2001 approximately 1,700 acres had been impacted by these types of sites in the past, and 1,130 acres of disturbed areas were still evident. Most of these sites were developed before 1977, thus, their effects on the vegetative landscape have persisted for decades, and are likely to persist for several more decades. As industry has shifted towards use of ice roads and ice pads during exploration (expected effects would be the same as from modern seismic exploration), loss of Special Status Species habitat has slowed greatly and is expected to have minor effects that could impact habitat for several years, but would be unlikely to accumulate because their effects are short-term and of limited geographic scope.

The oil and gas industry in Alaska conducts marine seismic surveys in the summer and fall, and on-ice seismic surveys (in the winter) to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or sub-sea terrain. Marine seismic surveys would involve both 2D and 3D survey methods. Because approximately 92,000 line-miles of 2-dimensional seismic data were collected in the Beaufort Sea between 1965 and 1997, future seismic surveys would be mostly 3-dimensional surveys. In the Chukchi Sea approximately 80,000 line-miles of 2D seismic data were between 1970 and 1990, and subsequent seismic surveys (post-2006) are likely to be 3D surveys (USDOI Minerals Management Service 2009). Seismic surveys during exploration activities in the MMS Beaufort Sea and Chukchi Sea Planning Areas are anticipated to result in a negligible effect on some Special Status Species in the action area (USDOI Minerals Management Service 2009).

Spectacled and Steller's eider along with yellow-billed loons are known to use the offshore waters of the Chukchi and Beaufort seas for spring and fall staging and fall molting. Impacts to these species would have potential to have greater negative effect and potentially increased accumulated effect if the disturbing or displacing activity occurs in an area where there are high densities of these species. If these effects have occurred, they may have accumulated.

Water used in the construction of ice roads and pads used for exploration activities is withdrawn from deep lakes in areas adjacent to the ice road and pad locations. It was feared that winter water withdrawal would alter lake levels and affect adjacent Special Status Species habitats, but investigations into this practice have documented lake recharge in the spring (Baker 2002, Hinzman et al. 2006). Since use of lakes in the past has varied, and few lakes would have had water withdrawn over multiple years, it seems unlikely that the effects of past use of lakes for water withdrawals would accumulate and negatively affect Special Status Species habitat.

Oil and Gas Development and Production. Loss and alteration of habitat, disturbance, and reduction in nesting success associated with predation are the mechanisms, by which the greatest effects to Special Status Species, have occurred on the developed portions of the North Slope in the past and persist today. To the extent that birds populations use habitat both in NPR-A and in these areas to the east of the Reserve or that birds displaced by these past activities currently use habitat in the planning area, impacts from this past oil and gas activity are part of the cumulative impacts for NPR-A's Special Status Species. Peat and gravel roads, gravel pads and airstrips, and gravel mines have caused the direct loss of Special Status Species habitat. For the North Slope as a whole, it is estimated that by 2001 gravel had been used to construct about 8,998 acres of roads and pads in the oil fields, 332 acres of the North Slope portion of the Dalton Highway, 1,765 acres had been impacted by other oil field related disturbances, and gravel mines had impacted another 6,364 acres (Table 4-41) for a total loss of 17,459 acres of habitat loss to industrial development. These numbers represent permanent loss of Special Status Species habitat unless the areas are rehabilitated in such a way as to return them to their original condition. Approximately 4,500 acres of gravel mines had been rehabilitated but only 70 acres of gravel pads (National Research Council 2003). Reclaimed gravel mines, much of it to deepwater lake habitat would have some value for eiders and yellow-billed loons. The rehabilitation of gravel pads has produced mixed results that have not restored areas to original conditions although gravel pads have resulted in the creation of habitat for those species that nest on gravel. Effects to Special Status Species from loss of habitat will accumulate as additional habitat is lost to gravel coverage, however newer developments are only expected to require one-tenth of the amount of gravel fill that was required for early oil fields (National Research Council 2003). Due to the limited amount of data on special status species populations and the large size of the area covered by oil field structures the magnitude of effects to Special Status Species from the past and present habitat loss on the North Slope is unknown matter of debate. The National Research Council (2003) concluded that the placement of oil field facilities does not appear to have reduced the overall densities of birds in those areas. Although not all areas disturbed in the past have provided habitat to Special Status Species a significant portion of the existing oil infrastructure is within the area used by spectacled eiders and yellow-billed loons. Whatever effects have occurred would be expected to persist as long as gravel remains in place.

In addition to the direct loss of habitat, construction of gravel structures has altered the moisture regime of the nearby tundra by changing natural drainage patterns and areas where snow accumulates. These changes have altered the species composition and occurrence of the plant community near gravel structures and may adversely affect Special Status Species. Additional impacts include dust deposition and the formation of impoundments. The passage of vehicle traffic over gravel pads and roads results in dust and gravel being sprayed over vegetation within about 30 feet of the pad or road, and a noticeable dust shadow out to 150 feet or more. These factors combine to warm the soil, deepen thaw, and cause thermokarst adjacent to roads and other gravel structures (National Research Council 2003). However, impoundments created by road and pad construction and dust deposition have created new feeding and brood-rearing habitat that has been beneficial to some bird species. Noel et al. (1996) reported that the areas occupied by impoundments in the Prudhoe Bay area generally supported higher waterfowl densities than the same areas did prior to development. The ratio of spatial extent of indirect effects (roadside flooding, dust, debris, thermokarst) to spatial extent of direct effects (gravel fill) average 6:1 (National Research Council 2003). Using this ratio across North Slope oil facilities and the Dalton Highway suggests that about 56,000 acres have been indirectly affected by gravel fill (8,998 acres gravel footprint plus 332 acres, times six; Table 4-41). These impacts, both beneficial and adverse, persist today and are expected to persist as gravel fill remains and vehicle travel occurs on the pads and roads.

Numerous types of disturbances could result from the construction and operation of oil and gas development and production facilities, including those caused by aircraft, vehicular, pedestrian, and vessel traffic. Some level of disturbance to Special Status Species from these activities would be unavoidable. Impacts have been most prevalent where facilities were located in habitats with high concentrations of Special Status Species, or if species with low population numbers or declining populations, such as threatened eiders, were disturbed.

Disturbance to waterfowl from aircraft is well documented (e.g., Schweinsburg 1974, Ward and Stehn 1989, Derksen et al. 1992, McKechnie and Gladwin 1993, Ward et al. 1999). Responses of birds to aircraft included alert postures, interruption of foraging behavior, and flight. Aircraft disturbances could displace birds from feeding habitats and negatively impact energy budgets. Johnson et al. (2003b) conducted the most thorough study of aircraft disturbance to waterfowl in Arctic oil fields at the Alpine field. Responses of birds to aircraft included alert postures, interruption of foraging behavior, and flight. Aircraft disturbances could displace birds from feeding habitats and negatively impact energy budgets. Johnson et al. (2003b) also reported on yellow-billed loons nesting in proximity to the Alpine field airstrip. Gollop et al. (1974b) and Ward et al. (1999) suggested that helicopters may be more disturbing to wildlife than low-flying fixed-wing aircraft, although Balogh (1997) indicated that fixed-wing aircraft flown at 150 feet above ground level often caused spectacled eiders to flush, while helicopters flown at similar altitudes in the vicinity of Prudhoe Bay did not. Preliminary results from studies on the Colville Delta found no change in distribution or nest success of spectacled eiders as the result of aircraft or vehicle operation (Johnson et al. 2006, 2007). The potential effects of routine aircraft flights into airstrips would range from bird avoidance of certain areas to abandonment of nesting attempts or lowered survival of young. Although the potential exists for displacement of some nesting Special Status Species near routinely used aircraft landing sites as a result of numerous overflights, landings, and takeoffs, some may habituate to routine air traffic. Given the relatively low density of Special Status Species (including spectacled and Steller's eiders) nesting in the NPR-A, disturbance resulting from aircraft activity would likely affect only a small percentage of the total populations of these species. Although the potential exists for displacement of some nesting birds near routinely used aircraft landing sites as a result of numerous overflights, landings, and takeoffs, some birds may habituate to routine air traffic, while others fail to do so. The cumulative impacts from repeated aircraft disturbance is currently unknown but likely has added only incrementally to impacts on special status species.

The National Research Council (2003) found that the inadequate disposal of garbage has resulted in artificially high densities of gulls, ravens, and mammalian predators in the oil fields. There is evidence that nesting success for several species of ground-nesting birds may be lower in oil fields than in undeveloped areas (Troy 1996, Anderson et al. 2000, Liebezeit et al. 2009). Increases in the number of predators in areas of development could have an additive impact on the effects of predation on Special Status Species populations. In recent years, North Slope oil field developers have installed predator-proof dumpsters to minimize attraction of predators. This policy has mostly been successful at the Alpine field, where Johnson et al. (2003b) reported no increase in the numbers of predator species, other than the common raven, after development. Although unmeasured predation of bird nests likely has had a negative cumulative effect on some of the Special Status Species populations in the developed areas of the North Slope and this effect is likely to have accumulated. Special Status Species mortality has resulted from collisions with buildings, power lines, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore and offshore oil and gas development. Known collision mortality to spectacled and Steller's eiders have occurred in Barrow and Deadhorse- probably the result of collisions with overhead lines and guywires (Minerals Management Service 2003 citing U.S. Fish and Wildlife Service unpublished data). No spectacled or Steller's eiders were found in a study of bird collisions with overhead powerlines at the Lisbourne development (Anderson and Murphy 1988). Offshore activities are most likely to impact Special Status Species during the late summer/fall staging period, when relatively large numbers eiders, and yellow-billed loons are staging and molting in marine areas. No spectacled or Steller's eiders were known to collide with the offshore Northstar installation over 3 years of monitoring (Day et al. 2004). Eiders have been reported colliding with fishing and research vessels in early spring (Lovvorn et al. 2003). Migration pathways may include areas where offshore production facilities are located, so collisions with offshore structures and with vessel and helicopter traffic used for transport of personnel and equipment, conducting oil spill response exercises or responding to an oil spill, could occur. Collisions with vehicles, buildings or oil field infrastructure probably do not represent a significant source of Special Status Species mortality at the population level. However, losses due to collisions in developed areas accumulate with increases in development and add incrementally to other impacts.

The largest spill in the North Slope oilfields (over 200,000 gallons) occurred in March of 2006, but this resulted in essentially no direct impacts to Special Status Species due to the timing of the spill, which allowed cleanup to take place before the spring melt. Indirect impacts to habitat are likely to have occurred as a result of the spilled oil and the subsequent clean-up effort. No notable spills into the marine environment have occurred. Small spills have occurred but cleanup and rehabilitation efforts have been successful and relatively few birds have been impacted (National Research Council 2003) and ecosystems have generally recovered (Jorgenson 1997). The cumulative effects of oil spills on the North Slope have added only incrementally to impacts on Special Status Species. There are no records of spectacled or Steller's eiders or their nests being directly impacted; however, clean-up efforts may have destroyed habitat, disturbed birds, and prevented localized nesting. Given the relatively low frequency of off-pad spill events and that spills have all occurred east of the Colville River in areas of relatively low eider densities (almost no Steller's eiders have been reported in these areas in many years), it is unlikely that any population effect would persist and accumulate for these species.

Offshore oil development and production, which occurs in both State and federal offshore marine waters of the North Slope, began in the early 1980s. Offshore activities rely on helicopter and marine vessels to transport equipment and personnel. Much of this activity takes place in the winter when Special Status Species are not present within the offshore marine waters of the North Slope. However, helicopter activity, barge and crew vessel traffic, and spill response training activities do occur during the summer. During the summer open-water seasons of 2001 and 2002 at the Northstar development off Prudhoe Bay, helicopter activity ranged from 477 to 989 round trips, crew vessel activity ranged from 469 to 824 round trips, and barge traffic ranged from 63 to 64 round trips (Williams 2002, Williams and Rodrigues 2003). Vessel traffic not related to oil development also occurs and could increase due to the recent extended open water periods in marine waters off the coast of the North Slope. These activities have likely displaced Special Status Species using the marine environment in the past, but the magnitude of the effect and the extent of any accumulation is unknown.

Factors Outside of the North Slope. Wintering grounds and portions of migratory routes of Special Status Species lie in areas outside of the North Slope, including areas within the U.S. and other several other countries and regulated or non-regulated development in these areas can negatively impact or destroy critical bird habitats. Various types of contaminants and toxins from industrial and agricultural activities can enter either terrestrial or marine environments and affect bird mortality or reproductive success. Oil spills have been an obvious source of mortality at numerous locations around the world. Commercial fishing activities have caused changes in predator-prey relationships that could affect wintering loons and eiders that feed in offshore marine habitats. Marine birds could also become entangled in fishing gear currently being used in commercial fishing activities or in abandoned gear that persists in marine environments. Subsistence users take some Special Status Species during spring and fall hunts, as well as eggs of some species during the nesting season. There is evidence that contamination of feeding habitat with spent lead shot may result in lead poisoning of spectacled eiders in some areas. All of these factors add to the cumulative loss of individuals, and in some instances, can have population-level effects.

Summary of Past and Present Impacts and Their Accumulation

Approximately 2,500 acres of habitat on the North Slope have been directly impacted by non-oil and gas development and those impacts continue to persist. Oil and gas activities have caused an additional habitat loss or alteration of over 17,000 acres that persist today. Although only a small portion of this area would have been used by Special Status Species, much of it has occurred along the coastline and near Barrow, areas where spectacled and Steller's eiders and yellow-billed loons are often found. Whether these impacts are associated with non-oil and gas residential and commercial development, or oil and gas activities, the impacts to habitat are additive to future impacts and would likely persist for several decades or more in the absence of an active reclamation program. The typical gravel pad and amount of roadway needed to service a development have become smaller over time, reducing the amount of habitat lost due to development as compared to past levels.

Direct and indirect effects from disturbance, of many different types, are difficult to measure, but are likely accumulating as the number of developments and the amount of developed area increase. New oil and gas developments have reduced their footprint size and the corresponding direct effects have been reduced, however these new developments often rely on aircraft support for transportation of personnel and equipment potentially increasing disturbance to feeding, nesting, staging and molting birds. The impacts of predators on Special Status Species populations may be waning as industry reduces the amount of predator-attracting garbage in the fields. Habitat loss and disturbance can add incrementally to the impacts of development on Special Status Species.

Whether past impacts to Special Status Species populations from habitat loss or disturbance are associated with non-oil and gas residential and commercial development, or oil and gas activities, these impacts are additive to any potential future impacts.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Non-oil and gas activities as described above would continue to result in the loss of small amounts of habitat and cause disturbance to Special Status Species. In many cases, loss of habitat from these activities would be temporary, lasting only a season or a few years. Habitat loss and disturbance associated with military facilities, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future. Villages are likely to increase in size, causing the loss of additional habitat, increase disturbance and will likely increase the predation rate of spectacled and Steller's eiders and nests in the vicinity of the human expansion. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 and then level off for the remainder of the 21st century. Subsistence harvest of spectacled eider adults and eggs apparently continues to impact these species, although overall numbers of birds and eggs taken over their entire range are not known. It is currently illegal to use lead shot while hunting waterfowl, although lead shot is allowed for hunting upland species. Illegal use of lead shot for hunting waterfowl, or legal use of lead shot for hunting upland species near waterfowl habitats could contribute to the effects of lead poisoning on eider populations. Programs currently are underway by the U.S. Fish and Wildlife Service and the North Slope Borough to inform hunters of harvest closures on these species in an effort to decrease this source of mortality. However, lead shot appears to persist in the environment and any additional lead shot would be additive to past amounts, incrementally increasing the chance of eider exposure and further reducing survival. An increase in marine vessel traffic is expected due to the recently extended open water period in the Chukchi and Beaufort seas.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploration. Based on projections developed for the NPR-A and extrapolated to the rest of the North Slope, on shore seismic exploration activity could take place on up to 86,400 acres annually. Exploration sites with ice pads, disturbed areas around these pads, ice airstrips, and ice roads would also be expected to be developed and are sources of habitat loss. Impacts from ice roads and pads are short-term (Yokel et al. 2007) and are not expected to accumulate. However, if climate warming shortens the winter season to the point where ice roads are not economically feasible for exploration drilling, the alternatives may cause greater habitat impacts than current practices. In this case, exploration and climate change would have synergistic effects on habitat loss from exploration activities.

Seismic activity has occurred for many years in the Chukchi and Beaufort seas and is expected to continue in the future during the open water season (June through October). Offshore and near shore seismic work includes the use of ice breakers, seismic vessels, support vessels and helicopters. Offshore seismic surveys are conducted using an airgun and receiving cable arrays. There is potential for Special Status Species to be impacted by offshore seismic surveys due to disturbance and potential displacement from preferred feeding, molting and staging areas if use areas overlap with seismic activities. However, acoustic noise from airgun arrays and exploration-related vessel traffic would be predominantly transient and would not typically occur in the same location with much frequency. Impacts have potential to have greater negative effect and potentially increased accumulated effect if the activity occurs in an area of high bird density or during a period when Special Status Species are flightless and less able to leave the area.

In the Chukchi Sea, exploratory drilling operations are likely to employ drillships with ice-breaker support vessels during the summer exploratory drilling season. Drilling operations are expected to range between 30 and 90 days at each well site. Considering the relatively short open-water season in the Chukchi (June through October), the Minerals Management Service estimated in their 2007 Lease Sale 193 EIS that up to four wells could be started by one rig each drilling season. However, it is more likely that only one to two wells could be drilled, tested, and abandoned during a single season. During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters would probably fly from Barrow at a frequency of 1-3 flights per day. Support vessel traffic would be 1-3 trips per week, also out of Barrow. Of particular concern is the potential effect of disturbance from offshore seismic activities to the designated critical habitat for spectacled eiders in Ledyard Bay (U.S. Fish and Wildlife Service 2001). Currently regulations prohibits any Outer Continental Shelf-related activity in the Ledyard Bay Critical Habitat Unit, including seismic surveying, exploration drilling, or support vessel traffic, additionally there are currently no Outer Continental Shelf Leases within this critical habitat unit. Most waterfowl are particularly sensitive to disturbance during staging or molt periods (Ward 1994, Ward et al. 1999). The Ledyard Bay area has been used by as many as 33,200 spectacled eiders and the molting population is believed to include the entire population of successful females and young from the Arctic Coastal Plain (Petersen et al. 1999). Overflights or vessel traffic through this area when eiders are present could result in disturbance effects to a large number of eiders which would be additive to other effects.

Exploration wells in the federal waters are likely to be vertical wells and in shallow OCS waters, exploration wells are likely to be drilled from man-made gravel or ice islands. In waters (greater than 15 meters) mobile, bottom-founded drilling structures could be used. Drillships with ice breaker support vessels are typically used in water depths greater than 25 meters. Artificial gravel or ice islands may be employed as drilling platforms in less than 15 meters of water, and their construction and supply would be supported by ice-roads across the landfast ice zone. In deeper water, bottom-founded structures and drillships would require supply vessels and helicopter support. Due to the sparse distribution and typical small flock size of special status species in the offshore waters of the Beaufort Sea offshore exploratory activities would not be expected to impact large numbers of individuals.

Vessel traffic associated with onshore or offshore development could disturb Special Status Species. The majority of barge traffic used to transport fuel, equipment, and supplies for onshore development would likely be staged from Prudhoe Bay, which has road access to ports at Anchorage. Barge traffic from Barrow would arrive from the west. Barge traffic would not occur until the open-water period begins in July, and would not cause any disturbance to eiders migrating in the spring. Eiders staging in Harrison Bay or Smith Bay prior to fall migration could be temporarily displaced from feeding habitats by barge traffic, although most spectacled eiders would likely be further offshore than projected barge routes. Barge traffic from the Prudhoe Bay area to support offshore development could potentially impact eiders by causing temporary or permanent displacement from preferred feeding habitats. The extent of the impacts would depend on the location of the offshore development, the number of trips, and the vessel route. These additional effects would be additive with respect to cumulative effects to North Slope eider populations.

Overall, effects on special status species from seismic activities and exploration in the NPR-A, lands to the east, and in the Chukchi and Beaufort seas would be additive and would likely accumulate. Development of a road between Umiat and the Dalton Highway could increase exploration operations along that road and also within NPR-A due to improved accessibility.

Oil and Gas Development and Production. Development activities that could contribute to cumulative effects to Special Status Species habitat on the North Slope include oil and gas development, including the NPR-A; federal and state offshore oil and gas development (including the construction of onshore infrastructure); state and native corporation onshore oil and gas development, both conventional and unconventional; oil and gas transportation, including commercial gas pipelines; and road construction. All of these activities involve construction of infrastructure that would destroy habitat within the immediate footprint of the project and indirectly affect Special Status Species and their habitats through disturbance (including predation), dust, flooding, changes in natural drainage patterns, thermokarst, snow drifting, and oil and chemical spills. There is evidence that predators of eiders, such as the Arctic fox, glaucous gull, and common raven, could be attracted to areas of oil and gas field development by anthropogenic sources of food and denning or nesting sites. Increases in the numbers of predators in areas of development could have an additive impact on the effects of predation on threatened eiders. In recent years, North Slope oil field developers have installed predator-proof dumpsters to minimize attraction of predators to development. Lease stipulations were established, in part, to prevent human-caused increases in predator populations and require the adoption of methods to avoid attracting wildlife to sources of food, and to use the best technology available to prevent facilities from providing nesting, denning, or shelter sites for ravens, raptors, and foxes. Monitoring at Alpine indicated no increase in density of fox dens during construction, but a pair of ravens continued to nest at the facility despite efforts to preclude them (Johnson et al. 2003).

The increase in the amount of area disturbed by oil and gas development on the North Slope has slowed in recent years. Before 1988, the oil field road network grew by about 24 miles per year but slowed to only 3 miles per year since 1988. The average rate of all gravel placement was about 421 acres per year before 1988, and only 42 acres per year between 1988 and 2001 (National Research Council 2003; Table 4-38). If the current rates continue into the future for areas outside the NPR-A, the ratio of gravel mine acres to gravel footprint acres remains about 5:1 (see section 4.2.1.2., Volume 2), and if Alternative D were to be implemented within the NPR-A, about 21,800 additional acres would be covered by gravel, and 4,350 acres impacted by gravel mines, between 2012 and 2100. Approximately 16,700 acres would be indirectly affected by dust, changes in hydrology, and thermokarst. Specific sources of direct and indirect habitat loss through future development are detailed below.

Umiat Road and Pipeline. This analysis assumes that a road and pipeline(s) up to 102 miles long would be built between Umiat and the Dalton Highway. The footprint of the road, ancillary facilities, and material sites would be almost entirely outside of the NPR-A and is estimated to cover 1,000 acres (Table 4-40). An oil pipeline along the same route would likely be above ground, whereas a gas pipeline would be buried and would affect about 185 acres of bird habitat in the long-term. Activities to maintain the road and pipeline would create disturbance impacts that would likely be similar to or greater than those from current oil field development depending on the types and amount of traffic allowed on the road. The Special Status Species that may potentially be directly affected by this action would be short-eared owl and golden eagle as they are the only Special Status Species that are likely to be found in any numbers in the area of the Umiat road and pipeline. A road and pipelines leading from the Dalton Highway to the boundary of the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in the amount of habitat lost to Special Status Species in the NPR-A through both direct and indirect actions.

Chukchi Sea Development. If development occurred in the Chukchi Sea some potential Special Status Species habitat may be altered or eliminated at the site of onshore facilities (administrative, maintenance and housing infrastructure and transportation facilities including a marine dock and airstrip along with roads connecting facilities) and pipelines. Onshore support infrastructure for Chukchi Sea development would likely be sited near and make use of existing infrastructure. While any habitat loss would be long-term, the areas disturbed would represent a small portion of the Special Status Species habitat present on the North Slope. Chukchi Sea development in federal waters could include up to 54 exploration and delineation wells, 880 platform production wells, and 235 subsea production wells, and construction of up to 1,000 miles of offshore pipelines and up to 500 miles of onshore pipelines (see section 4.8.3.2). Disturbance to Special Status Species (primarily spectacled and Steller's eider, yellow-billed loon) by these onshore facilities would likely be dependent on their location as some areas of the Chukchi Sea coast are very important for large numbers of nesting and brood-rearing spectacled and Steller's eiders and facilities located close to these important areas could cause disturbance that could negatively affect those species on a population level. Careful siting of any new facilities to avoid important habitats would reduce the magnitude of any potential effects on local Special Status Species populations. Any offshore construction activities that take place in summer (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mile) of the construction site (Bureau of Ocean Energy Management 2011). Localized burial of potential prey and destruction of foraging habitat as a result of pipeline trenching or island construction (if utilized in State-owned waters) are not expected to cause a significant decline in prey availability. It is likely that most construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when Special Status Species are absent. Winter construction would utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats and the potential effects to tundra habitats would be the same as those outlined in previous sections.

Potential impacts on Special Status Species using marine and coastal areas from activities in the Chukchi Sea include behavioral disturbance due to the presence of, and noise generated by, equipment, vessels, aircraft and human activity. Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989, Ward et al. 1994, Miller 1994, Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb species feeding in limited areas of open water causing birds to leave the area. Similarly, overflights in summer could displace Special Status Species from preferred foraging areas and from coastal nesting or brood-rearing areas such as the lagoon systems of the Chukchi Sea. The type of response elicited and the potential effect on Special Status Species will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (Minerals Management Service 2002b). Marine vessel trips could disturb yellow-billed loon, spectacled and Steller's eider in preferred foraging, molting, and staging areas, potentially causing them to leave the area and move to potentially less favorable habitats. However, the amount of vessel and aircraft traffic that could occur under the proposed action would be relatively limited. The Special Status Species that would most likely be affected by vessel and aircraft traffic would be yellow-billed loon, spectacled and Steller's eider and the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to the traffic.

Mortality could result from collisions with buildings, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore or offshore oil and gas development. Offshore activities would be most likely to impact spectacled and Steller's eiders during the late summer and fall staging periods, when relatively large numbers of eiders are found in marine areas. Migration pathways of these eiders may include areas where offshore production facilities are constructed, so collisions between eiders and offshore structures, and watercraft and helicopters used for transport of personnel and equipment or responding to an oil spill could occur. Specific lighting protocols are in effect for offshore infrastructure to mitigate the potential collision risk. The potential number and locations of offshore sites and their effects on spectacled and Steller's eiders would be additive to existing effects in North Slope oil fields. Exploration and development in the nearshore areas of Chukchi would have the greatest potential for collisions. Eiders fly in small flocks, low and fast over water (Day et al. 2004) and movements during spring and fall migrations are more likely to occur in darkness or poor weather conditions, all factors that can influence strike rates.

Any disturbance from new developments in the Chukchi Sea would represent additive effects. Continued activity to support future development likely would result in additional low-altitude flights over nesting, brood-rearing, staging, or migrating yellow-billed loons, spectacled and Steller's eiders. Long-term displacement (1 year or more) from heavily used corridors could result in fewer young produced and somewhat lower survival of adults. However, some individuals might tolerate this level of disturbance and nest, rear broods, or forage within the air traffic corridor. Given the relatively low density of yellow-billed loons, spectacled and Steller's eiders nesting in the NPR-A, disturbance resulting from aircraft activity would likely affect a small percentage of their populations.

If a pipeline is built east across the NPR-A and on to the Trans-Alaska Pipeline System, it would add little long-term impacts to Special Status Species habitat. A small amount of habitat would be permanently lost within the footprint of the new pipelines. If a road were to be built along the pipeline route, the total impact may add up to 3,000 acres, potentially resulting in more substantial loss of Special Status Species habitat (see Table 4-40). A pipeline and road across the NPR-A could make additional developments within the NPR-A more economical, causing a synergistic increase in acres of Special Status Species habitat lost in the NPR-A.

Beaufort Sea Development. If offshore development occurs in the Beaufort Sea there may be a need for onshore processing facilities and certainly would require onshore pipelines. Offshore production platform would be accessed by helicopter, barge, and in nearshore areas, by a winter ice road. A subsea pipeline would bring the oil or gas into an onshore pipeline gathering system, where it would be processed, either in existing facilities or, if too distant from existing facilities, new processing facilities. The Beaufort Sea development program would permanently eliminate potential Special Status Species habitat at the sites of offshore platforms and pipelines and construction of onshore gathering and processing facility and pipelines. While this habitat loss would be long-term, the areas disturbed would represent a small portion of the Special Status Species habitat present on the North Slope. Offshore development in federal waters could include the placement of up to 40 exploration and delineation wells, 310 platform production wells, and 25 subsea production wells, and the construction of up to 423 miles of offshore pipelines and 290 miles of onshore pipelines.

Disturbance to Special Status Species (spectacled and Steller's eider, yellow-billed loon) by these onshore facilities would likely be dependent on their location as some areas of the Beaufort Sea coast are very important for large numbers of nesting and brood-rearing yellow-billed loon, spectacled and Steller's eiders and facilities located close to these important areas could cause disturbance that could negatively affect those species on a population level. Careful siting of any new facilities to avoid important habitats would reduce the magnitude of any potential effects on local Special Status Species populations. Any construction activities that take place in summer (e.g., platform installation for field development) could displace birds from within about 1 km (0.62 mile) of the construction site (Bureau of Ocean Energy Management 2011). Localized burial of potential prey and destruction of foraging habitat as a result of pipeline trenching or island construction are not expected to cause a significant decline in prey availability. It is likely that most construction, particularly of gravel islands, roads, pads, and pipelines, would take place during winter when Special Status Species are absent. Winter construction would utilize ice roads to build and access gravel island construction sites. Ice roads may be constructed over both tundra habitats and frozen ocean habitats and the potential effects to tundra habitats would be the same as those outlined above.

Potential impacts to Special Status Species using marine and coastal areas from activities in the Beaufort Sea include behavioral disturbance and collisions due to the presence of, and noise generated by, equipment, vessels, aircraft and human activity.

Helicopter or fixed-wing aircraft overflights are generally conducted at low altitudes and could disturb birds in onshore and offshore locations (Ward and Stein 1989, Ward et al. 1994, Miller 1994, Miller et al. 1994). Helicopter and aircraft overflights during spring breakup of pack ice may disturb Special Status Species feeding in open waters causing birds to leave the area. Similarly, overflights in summer could displace waterfowl and loons from preferred foraging areas and from coastal nesting or brood-rearing areas. The type of response elicited and the potential effect on the Special Status Species will depend in large part on the time of year for the overflights and the species disturbed. Birds experiencing frequent overflights may permanently relocate to less favorable habitats (Minerals Management Service 2002b). Marine vessel trips could disturb yellow-billed loons, spectacled and Steller's eiders in preferred foraging, molting, and staging areas, potentially causing them to leave the area and move to potentially less favorable habitats. However, the amount of vessel and aircraft traffic that could occur under the proposed action would be relatively limited. The Special Status Species that would most likely be affected by vessel and aircraft traffic would be yellow-billed loons, spectacled and Steller's eider and the nature of their response, and the potential consequences of the disturbance will be a function of a variety of factors, including the specific routes, the number of trips per day, the seasonal habitats along the routes, the species using the habitats and the level of their use, and the sensitivity of the birds to the traffic. Collisions between birds and offshore and coastal structures are known to occur, especially during inclement weather and may involve many individuals of some species, including spectacled eiders. Lighting can be designed to mitigate this collision potential.

Mortality could result from collisions with buildings, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore or offshore oil and gas development. Offshore activities would be most likely to impact spectacled and Steller's eiders during the late summer and fall staging periods, when relatively large numbers of eiders are found in marine areas. Migration pathways of these eiders may include areas where offshore production facilities are constructed, so collisions between eiders and offshore structures, and watercraft and helicopters used for transport of personnel and equipment or responding to an oil spill could occur. The potential number and locations of offshore sites and their effects on spectacled and Steller's eiders would be additive to existing effects in North Slope oil fields. Exploration and development in the nearshore areas of the Beaufort Sea would have the greatest potential for collisions. Eiders fly in small flocks, low and fast over water (Day et al. 2004) and movements during spring and fall migrations are more likely to occur in darkness or poor weather conditions, all factors that can influence strike rates.

Any disturbance from new developments in the Beaufort Sea would represent additive effects. Continued activity to support future development likely would result in additional low-altitude flights over nesting, brood-rearing, staging, or migrating yellow-billed loons, spectacled and Steller's eiders. Long-term displacement (1 year or more) from heavily used corridors could result in fewer young produced and somewhat lower survival of adults. However, some individuals might tolerate this level of disturbance and nest, rear broods, or forage within the air traffic corridor. Given the relatively low density of yellow-billed loons, spectacled and Steller's eiders nesting in the NPR-A, disturbance resulting from aircraft activity would likely affect a small percentage of their populations.

Alternative B-2 of this plan would preclude leasing along the entire length of the NPR-A coast from Barrow to the lands owned by Nuiqsut's village corporation just west of the Colville River. However, Alternative B-2 does allow for new non-subsistence infrastructure to be developed on the coast between Barrow and the east side of Smith Bay and along Kogru Inlet which would allow for offshore development in the Beaufort Sea to come onshore in this area. Thus, a distribution system could be developed to tie the offshore development into the Trans-Alaska Pipeline System which may make smaller oil and gas fields in the northeastern NPR-A more economical. This may provide a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's scenarios and may lead to greater impacts to Special Status Species and their habitats.

Commercial Gas Pipelines. It is estimated that impacts to bird habitat on the North Slope from the Alaska Pipeline Project (a commercial gas pipeline) would total 4,500 acres during construction and half that figure during operations. These figures were arrived at by assuming impacts to the 200-foot right-of-way during construction and to the 100-foot permanent pipeline right-of-way. Construction camps, pipe storage areas, and contractor yards will, to the extent possible, be located at previously disturbed sites. The project would include a gas treatment plant at Prudhoe Bay. Gravel pads and roads for the treatment plant would directly impact 200 acres of land; 155 acres would be for the gas treatment plant site and the remainder for access roads. In addition, a 25-acre pad near West Dock would be constructed for a module staging area. Gravel will be obtained from existing borrow sites. Once buried, the pipeline would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor and would not accumulate. Estimates of the gravel footprint and borrow site footprint combined from the Alaska Gasline Development Corporations project would total 110 acres. All of this would likely occur to the east of the NPR-A. A potential impact to Special Status Species (specifically spectacled eider and yellow-billed loon) may come from the proposed dredging of a channel in the Beaufort Sea in order to transport gas treatment plant modules to the Prudhoe Bay area using sealifts. The dredging would likely occur in the summer when Special Status Species are using the nearshore waters for feeding, staging, brood-rearing and molting. If a dredging operation occurred in locations where large groups of Special Status Species were gathered they would likely be disturbed and move from the area and the survival and fitness of individuals may be affected and may result in significant population losses. Overall, much greater impacts to Special Status Species and their habitats from this pipeline would be the area affected by the gas development infrastructure and associated impacts that a commercial gas pipeline may make possible within the NPR-A and to the east.

Conventional Oil and Gas Development between the Colville and Canning Rivers. The increase in the amount of area disturbed by oil and gas development on the North Slope has slowed in recent years. If the current rates continue into the future for areas east of the NPR-A and the ratio of gravel mine acres to gravel footprint acres remains about 1:5, about 3,750 additional acres of bird habitat would be lost through the construction of pads, roads and airstrips through the year 2100 and 750 acres by gravel mines. About 27,000 acres (6:1 ratio) would also be indirectly affected by dust, changes in hydrology, and thermokarst. The effects of this continued development would be expected to have the same small incremental effect on Special Status Species and Special Status Species habitat as is currently occurring.

Unconventional Oil and Gas Development East of the NPR-A. There are many challenges to this type of development on the North Slope, but for this cumulative analysis it is assumed that unconventional oil and gas development will become viable on better drained lands south of Prudhoe Bay and near the Dalton Highway. It is further assumed that this development will result in the loss of about 3,600 acres of habitat over the next 15 years. Better drained lands on the North Slope provide uncommon habitats that are used by a specific suite of bird species; however, none of the Special Status Species analyzed in this section are known to use those uncommon habitats. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on time and location of the impacts and the type of technology used.

Oil Spills and Gas Releases. Birds could be negatively affected by accidental oil spills from offshore platforms and pipelines, as well as from onshore processing facilities and pipelines. In general, loons, waterfowl, seabirds, and shorebirds are not expected to survive moderate to heavy oil contact. Oiled feathers lose their insulative and water repellent characteristics, and birds die of hypothermia (Albers and Gay 1982). Swallowed oil is toxic and causes impaired physiological function and production of fewer young. Oiled eggs have significantly reduced hatching success (Albers 1980). Vulnerability of bird populations to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of spill contact also is variable and depends on location, oceanography, weather patterns, and habitats typically occupied by and habits of, the particular species. Because they are unable to fly, molting birds probably are the most vulnerable. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., nesting, molting, brood-rearing). A large onshore oil spill during the summer season could affect all Special Status Species except for Kittlitz's murrelet. In the immediate vicinity of the spill, habitat contacted by oil would become unsuitable for bird use, and oil entering aquatic habitats could spread widely, potentially entering river deltas and nearshore marine habitats. Direct mortality could occur from loss of insulating capabilities of feathers should birds come in contact with oil, or from ingestion of contaminated prey. Oil that came in contact with eggs, either directly or through contact with partially oiled feathers of incubating adults, could negatively impact embryonic development. These effects would be additive to the effects of any other oil spill on the North Slope and by oil spills in other coastal lagoons and marine areas in molting or wintering areas where Special Status Species are present.

Cumulative effects would depend on the number, size, location, and timing of spills, the type and effectiveness of the oil spill response, and the species and population size of birds exposed to the spill. If losses are substantial in a species with a low reproductive rate recovery may take many years, or populations may not recover to their pre-spill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate. Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution. Species dependent on widely dispersed prey would have more limited effects. Individual birds actively feeding young and dependent upon nearby food resources would be limited in their ability to seek uncontaminated prey elsewhere. If a leak from an onshore pipeline or facility were to occur on a pad, the extent of the spill likely would be restricted by containment berms. If the spill occurred along the off-pad portion of the pipeline, the area covered may include several acres; if the spill were to enter streams or lakes, a larger area could be affected as the oil spreads over a water surface or is carried down a watercourse. From mid- to late summer, such an occurrence could contact brood-rearing females and their young, as well as potentially large flocks of nonbreeding and post breeding individuals undergoing wing molt. Ten large spills would be expected as a result of the offshore Beaufort Sea and Chukchi Sea Planning Areas OCS program over the next 50 years (Table 4-42). Loons, waterfowl, and shorebirds using onshore habitats are generally at low risk of contacting a spill while nesting, but risk of exposure increases as they leave the mainland nesting areas and concentrate in coastal or marine habitats for brood rearing, molting, or staging.

Molting and migrating spectacled eiders and yellow-billed loons use Simpson and other Beaufort Sea lagoons, Harrison and Smith Bays, Kasegaluk Lagoon, and Peard and Ledyard Bays in the Chukchi Sea during molt. Substantial numbers of non-breeding, foraging, or staging birds that occupy offshore areas in both the Beaufort and Chukchi seas, when open water beyond the barrier islands is available, could be exposed to an oil spill. An offshore spill could also affect feeding habitats in littoral habitats, such as extensive mudflats in the Colville River Delta, which are used by staging shorebirds. The Colville River delta supports thousands of post breeding shorebirds including the red knot (Andres 1994). An oil spill could also contaminate prey populations in foraging areas at any time of year, which could result in secondary impacts to Special Status Species by affecting productivity and/or survival. During spring migration, substantial numbers of yellow-billed loons and spectacled eiders moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives available to the birds until open water off river deltas is available in late spring. Likewise, a similar rather restricted open water situation exists in both the Beaufort and Chukchi Seas for Special Status Species migrants that pause awaiting further melting to the north or east, and for birds occupying delta waters and near shore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats. Major effects on some bird populations during the open water season are expected to follow a spill. For all Special Status Species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, and feeding). Survival and fitness of individuals may be affected and significant population losses may occur. In addition, it is unlikely that all spilled oil would be removed from the environment, and a spill occurring in winter, when Special Status Species are absent from the planning area, still may have serious impacts if substantial quantities of oil are entrained in the ice and then released during the following breeding season.

If one or more spills were to occur in the offshore environment during the summer/fall season when flocks were present, substantial losses could result to spectacled and Steller's eiders and yellow-billed loons. The number affected could potentially total tens to hundreds of individuals. Using average estimated spectacled eider density calculated from the U.S. Fish and Wildlife Service survey data in the central Beaufort Sea area from Harrison Bay to Brownlow Point, and average severity of spill-trajectory paths (and thus, exposure of birds to oil), a U.S. Fish and Wildlife Service model estimated an average of two eiders would be exposed to a large spill (5,912 barrels) within 30 days in July (Stehn and Platte 2000). However, in late July one group of 100 individuals was observed, suggesting a potential for much higher mortality should a spill occur in an area of relatively high spectacled eider density. An offshore oil spill with the greatest potential to impact spectacled eiders would be one that occurred in the deeper offshore waters of Harrison Bay, rather than in the offshore waters to the east or the shallower nearshore waters. An oil spill could also contaminate prey populations in eider foraging areas at any time of year, resulting in secondary impacts to eiders by affecting productivity and/or survival. Likewise, a spill affecting shoreline or coastal marsh habitat could affect eiders that were moving from onshore brood-rearing areas to the marine environment, or that inhabited the area in subsequent years. Molting and/or staging spectacled or Steller's eiders are known to use the lagoon systems in offshore areas of the Beaufort and Chukchi seas and Norton Sound. A large oil spill that entered Ledyard Bay could have significant population effects on not just the Arctic Coastal Plain population of spectacled eiders but also the world population.

In addition to the potential impacts from spilled oil the oil spill cleanup process may also affect Special Status Species in both the onshore or offshore environments. The presence of large numbers of personnel, boats, and additional aircraft following a spill is expected to displace Special Status Species occupying affected habitats for one to several seasons. Cleanup efforts late in the breeding season may disturb brood-rearing, juvenile, molting or staging birds. It is extremely difficult to separate the effects of oiling and disturbance from cleanup activities, but either separately or together they have the potential to influence Special Status Species and their habitats (Wiens 1996).

The oil industry is required to have oil spill response and clean-up capabilities, and small spills on lands or waters in the NPR-A or in existing or future North Slope oil and gas fields and other industrial developments are expected to be contained and cleaned up before substantial bird and habitat loss can occur. In addition to mortality through direct contact with oil, some mortality could result from the accumulation of effects of the numerous small spills expected from the operation of any oil field. Indirect impacts to Special Status Species through permanent habitat loss would likely be negligible due to the small number of acres likely to be affected. Under the reasonably foreseeable future scenario the amount of oil produced onshore on the North Slope is expected to continue to decrease from historic high levels. As oil production slows, coupled with improvement in spill prevention, control technologies and training, the potential for effects to Special Status Species should decline over time. This potential downward trend could be countered, however, if an aging pipeline system led to an increase in pipeline leaks. Any accidental gas releases that occur in the future would likely affect only those individuals that are nearby at the time of the release. Any impacts to Special Status Species populations would likely be negligible and would not accumulate.

Abandonment. The ultimate fate of the gravel pads, roads, and airstrips will not be known until closer to the end of the life of the oil and gas fields. Permitting agencies could require that gravel be removed, in part or in total, and the tundra revegetated. If other uses are determined by the permitting agencies to be preferable, the agencies could allow the permittee to leave the gravel pads in place, either revegetated or not revegetated. Removed gravel either would be disposed of or reused for another development. The impacts of abandonment and rehabilitation of oil and gas fields on Special Status Species would be similar in many respects to those incurred by construction activity, although activities occurring in the winter would not cause disturbance or displacement, because Special Status Species would be absent from the area. Summer road and air traffic generated by abandonment and rehabilitation activities could cause disturbance, displacement, and mortality to Special Status Species that would be similar to, and at the same levels as that caused by traffic during construction and operations. If pads, roads, and airstrips were not revegetated, their value to Special Status Species would be lessened. If they were revegetated without removing the gravel, the habitat would not return to its current utility for most birds of the area. If gravel was removed, habitat similar to that currently existing in the area could be created and used by Special Status Species, though the precise mix of habitat types would likely not be the same as what prevailed at the time of disturbance. The effects of habitat loss would accumulate, as described above, to the extent that habitats were not, or could not be, restored to their original condition.

Numerous other factors could add to cumulative impacts on Special Status Species populations on the North Slope. Subsistence harvest of yellow-billed loon, spectacled and Steller's eiders continue to impact these species, although overall numbers of birds and eggs taken over their entire range are not known. Aside from direct mortality due to subsistence harvest, the accumulation of lead shot in waterfowl foraging habitat in the Y-K Delta may be impacting waterfowl survival. It is currently illegal to use lead shot while hunting any bird species on the North Slope. Illegal use of lead shot for hunting waterfowl, could contribute to the effects of lead poisoning on Special Status Species populations.

Factors Outside of the North Slope. Wintering grounds and portions of migratory routes of Special Status Species lie in areas outside of the North Slope, including areas within the U.S. and several other countries, and regulated or non-regulated development in these areas can impact critical Special Status Species habitats. Habitat losses in non-breeding areas could be particularly significant for special status species. Habitat losses may occur directly from habitat destruction due to development, or from pollution, such as exposure to agricultural pesticides that may reduce the ability of birds to reproduce or may cause direct mortality to birds. Other activities, such as commercial fishing, may also have the potential to cause changes in predator/prey relationships or damage benthic habitats that could affect some marine bird populations. Numbers of wind farms are increasing in many areas of the United States, including Alaska and in many other areas of the world. These wind farms have the potential to cause direct mortality to birds. Diseases such as West Nile Virus and avian influenza have the potential to be transmitted to and from the planning area by species that spend a portion of their life cycle in Asia. Impacts related to subsistence hunting and sport hunting in wintering areas and along migratory routes can be additive to the effects of development on the North Slope. Spent lead shot that remains in waterfowl feeding habitat has been linked to lead poisoning for some waterfowl species (Franson et al. 1998). Impacts of subsistence hunting may impact spectacled and Steller's eiders. Cumulative effects to Special Status Species would be additive and include habitat loss and disturbance related to activities on the migration and wintering grounds that could result in permanent or temporary displacement from preferred habitats.

Contribution of Plan Alternatives to Cumulative Effects

Short-term impacts from ice road construction would occur on 231,995 to 456,683 acres during the life of the plan, while impacts from ice airstrips would occur on another 715 to 1,375 acres. Short-term impacts from oil and gas exploration wells would occur on 384 to 768 acres depending on Alternative (Table 4-14 in Volume 2), with 456 acres estimated for Alternative B-2, these impacts to bird habitat likely would not accumulate. Long-term impacts to Special Status Species habitat from oil and gas infrastructure surface disturbance in the NPR-A would occur on approximately 7,505 to 16,329 acres under the five alternatives, with 8,402 acres estimated for Alternative B-2 (Table 4-14 in Volume 2). These long-term impacts would accumulate. Total, long-term, direct and indirect impacts to vegetation from exploration and development combined would occur on 0.12 percent (Alternative B-1) to 0.26 percent (Alternative D) of the NPR-A. These habitat losses would account for up to 53 percent of the habitat projected to be lost due to development on the North Slope during the next 88 years.

Functional loss of habitat as a result of displacement due to disturbances, could involve a much greater area. Given that the area most likely to be developed for oil and gas under the action alternatives (economic zones 110 and 120, section 4.2.1.2, Volume 2) includes the most important nesting and brood-rearing areas for yellow-billed loons, spectacled and Steller's eiders impacts to those species, and their habitats could be much greater than predicted based solely on amount of area disturbed. Because of the importance of these areas, Lease Stipulations/required operating procedures/best management practices E-2, E-11, G-1, J, K-2, K-3a and b, K-4a and b, K-6, K-8a and b, and K-11 were developed to provide special surface occupancy protection to Special Status Species habitat, though not all of these protections would apply to Alternative D. Still, individuals of most Special Status Species would be exposed to oil and gas disturbance during the breeding period. Depending on the types and locations of facilities, impacts could accumulate, especially where Special Status Species are concentrated such as molting lakes and staging areas, and could affect the long-term health of the local population.

The effects to Special Status Species and their habitats from oil and gas development would be least under Alternatives B-1 and B-2, because much of the high density nesting areas for spectacled eiders and yellow-billed loons would be unavailable for leasing under this alternative. The effects would be greatest under Alternative D, since the entire NPR-A would be open to leasing with fewer mitigations than under other alternatives. Impacts to vegetation (Special Status Species habitat) and direct disturbance of Special Status Species on the North Slope from future oil and gas exploration and development are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past, present, and future oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of habitat impacted by all oil and gas development, and would be additive in nature for the most part. However, depending on oil prices and where and how much oil is ultimately developed in the NPR-A and offshore, there could be synergistic effects on acreage of habitat affected and levels of disturbance to Special Status Species in the NPR-A. This would occur if a discovery in the Chukchi or Beaufort sea, and the subsequent transportation system (pipelines) would make economically feasible the development of additional oil or gas fields in the northern part of the

NPR-A which would not otherwise have been economically developable. Such a scenario could result in additional development in an area that is important nesting and brood-rearing habitat for spectacled eiders.

Similarly, development in the northern portion of the NPR-A could have a synergistic effect on spectacled eiders and yellow-billed loons using the Colville River delta, either by providing economic incentive for increased oil/gas development in the latter, or by the need for increased infrastructure or air or ground traffic in the delta to transport oil or gas, or supplies and equipment, to or from the NPR-A. In addition to these areas, the potential exists for development of production facilities or a staging base on private land at Cape Halkett at the northeastern tip of the NPR-A. These private lands do not have the requirement for a three-quarter-mile buffer along the coast. Development on these private lands would potentially impact nesting and brood-rearing spectacled eiders in a manner that would be additive, or perhaps synergistic, to effects from development on adjacent BLM-managed lands. Implementation of Alternatives A, B-2, C, or D would not preclude development in the Beaufort Sea as those alternatives, in contrast to Alternative B-1, allow for access to NPR-A lands for transport of Beaufort Sea oil or gas to market. This would represent an additive effect to total development in the NPR-A.

Synergism affecting brood-rearing, molting and migrating spectacled eiders and yellow-billed loons could similarly result if development north of Teshekpuk Lake resulted in offshore development being more economically feasible. Such offshore development would likely result in additional habitat and disturbance impacts from developments built onshore in support of offshore activities and from interactions of Special Status Species with offshore developments including collisions and oiling. This would most likely affect the Beaufort Sea coastal portions of the NPR-A. This scenario is not possible under Alternative B-1 in which new non-subsistence infrastructure would not be permitted along BLM-managed lands east of Barrow. Synergistic development onshore as a result of offshore development is also severely reduced under Alternative B-2, because none of the Beaufort Sea coastal area in the NPR-A would be available for lease. It would be most likely under Alternative D because no areas would be unavailable for leasing under that alternative and there are fewer development restrictions. It would be less likely under Alternative A because of development constraints and less yet under Alternative C because of development constraints and some coastal lands being unavailable for lease.

Cumulative effects from this plan on Special Status Species distribution and abundance are likely to be long term, lasting as long as the life of the oil and gas fields. Any reduction in breeding as a result of future onshore or offshore development would represent a functional loss of habitat that accumulates and could result in long-term effects on a suite of Special Status Species' productivity and abundance. These impacts would likely be greatest under Alternative D and lowest under Alternative B-1. The effects of oil and gas activities in the NPR-A would be greatest on those Special Status Species that use the NPR-A in disproportionally high numbers (spectacled and Steller's eider and yellow-billed loon) or if their populations are low or decreasing (Steller's eider). If climate change over the next several decades were to result in widespread changes in vegetation composition and insect and other invertebrate abundance, disturbance effects of oil and gas activities to Special Status Species could be exacerbated through the additive effects of oil and gas activities to habitat, and could extend beyond the life of the oil fields.

Conclusion

Impacts to Special Status Bird Species and their habitat may accumulate from the following sources: past non-oil/gas activities, non-oil/gas activities from now until about 2100, past oil/gas activities outside of the NPR-A, future conventional oil/gas activities onshore and offshore of the North Slope including the NPR-A, future unconventional oil activity east of the NPR-A, construction of a road and pipeline(s) from Umiat to the Dalton Highway, and construction of a commercial gas pipeline. All future impacts are additive to the impacts to Special Status Species and their habitat that have accumulated in the past and persist today, but in the context of the entire North Slope west of the Canning River, these cumulative impacts would be relatively small. Based on impacts to 42,050 acres that could still persist in 2100 (Table 4-40), direct impacts to habitat would occur on 0.1 percent of the North Slope west of the Canning River. This estimate does not take into account the quality of habitat or specific habitat requirements of Special Status Species that would be impacted on the North Slope. It is likely that the focus of future oil exploration and development would remain relatively near to the coast, and much gas development will likely occur in the same area. Future gas exploration, however, may be concentrated further south in the foothills. A wide variety of habitat types having variable value to Special Status Species could ultimately be affected.

It is reasonable to assume that increased development would cause increased disturbance to Special Status Bird Species. Although there is no clear indication that disturbance effects have accumulated to the point that they are adversely affecting Special Status Species populations, the effects of potential future developments outside of the planning area and offshore development in the Chukchi and Beaufort seas would be additive to effects of present and past development. If Special Status Species are displaced from prime habitat and disturbance further displaces them, the effects of displacement and disturbance could result in energetic costs that reduce survival and productivity. These losses of individuals would accumulate, and could persist as long as development and associated disturbance occur on the North Slope. Increases in the predation of Special Status Species and nests would be expected in areas of increased human activity as predators tend to concentrate in areas of human development on the Arctic Coastal Plain.

Although there is no clear indication that predator effects have accumulated to the point that they are adversely affecting Special Status Species populations, the effects of potential future developments outside of the planning area would be additive to effects of present and past development. If Special Status Bird Species are killed or nests predated due to increased numbers of predators in the vicinity of oil and gas infrastructure losses of individuals would accumulate, and could persist as long as development occurred on the North Slope. Mortality from collisions with buildings, vehicles, aircraft, vessels, towers, pipelines, platforms, or other structures associated with onshore and offshore oil and gas development is likely to persist into the future, and is expected to increase with increasing levels of development. The oil and gas industry has developed and implemented anti-collision practices, including providing better lighting of facilities, burying power lines, and attaching power lines to pipelines, in an attempt to reduce the number of Special Status Species collisions oil and gas infrastructure. Losses from collisions with offshore infrastructure are expected to be small and would not be expected to significantly affect Special Status Species populations. However, if Special Status Bird Species are killed due to increased oil and gas infrastructure, losses of individuals would accumulate, and could persist as long as development occurred on the North Slope. Impacts also have potential to have greater negative effect and potentially increased accumulated effect if the activity occurs in areas containing high densities of Special Status Species.

Although direct habitat loss from cumulative oil and gas development on the North Slope would affect only a small proportion of the total area, indirect habitat loss, or functional loss, could result from long-term displacement of Special Status Species from the vicinity of oil and gas activities and could involve a much larger area. Future gas and both conventional and unconventional oil exploration and development between the Colville and Canning rivers, in addition to construction of an Umiat road and commercial gas pipelines, would increase the amount of activity Special Status Species on the North Slope are subjected to. Offshore leases in the Beaufort and Chukchi seas could expose Special Status Species to additional activities related to oil and gas development (through offshore drilling platforms, onshore facilities to support offshore leases and through increased aircraft and marine vessel traffic). Future development in the NPR-A could expose Special Status Species to disturbance from development activities during sensitive nesting, brood-rearing, molting and staging periods.

The effects of disturbance from noise, aircraft, vehicle, and ship traffic, and other sources are likely to affect significantly more eiders than direct habitat impacts. However, the available information suggests that past disturbance effects have at least not caused population declines (population growth not significantly different than 0 after 14 years; Larned et al. 2006), and vehicle and aircraft activity do not appear to result in changes in nesting eider density or nesting success (Johnson et al. 2006). These studies are limited by precision (Larned et al. 2006) and short study period (Johnson et al. 2006), however. Changes may occur to slowly to be detected results confounded by environmental variation. Future development in higher density eider areas may have different results. Further minor impacts resulting from existing development may have significant effects if future development results in population effects from a large offshore oil spill or disturbance of critical habitat resulting in abandonment and reduced fitness of a significant portion of the population.

Development of onshore oil resources in the western portion of the NPR-A or offshore development in the Beaufort or Chukchi seas would result in construction of one or more additional aboveground pipelines that would pass through the NPR-A. Construction of a pipeline from (or through, in the case of offshore development) the western portion of the NPR-A east to the Kuparuk River Unit, or a southern pipeline route connecting to the Trans-Alaska Pipeline System Pump Station 2, may temporarily disturb Special Status Species. Pipelines associated with any of these oil developments may or may not have roads associated with them, but if roads are built, the expected effects would increase. Climate change may eventually lead to large shifts in the composition of Arctic tundra toward increased shrub height and cover extent, tree encroachment north of the Brooks Range and increased grass and sedge species (Chapin et al. 1995, Naito and Cairns 2011, Sturm et al. 2001, Walker et al. 2006, Scenarios Network for Alaska Planning 2011). These changes in vegetation would directly impact the amount and types of habitat available to tundra nesting Special Status Species. Predicted warmer soil temperatures are likely to increase thermokarst, and increases in sea level may inundate low-lying tundra areas, increasing salt marsh, aquatic, and wet tundra vegetation types and erosion of coastal bluffs (Arctic Climate Impact Assessment 2004) causing changes to or elimination of nesting and feeding habitat for many Special Status Species. Such impacts of climate change could accumulate with any changes in soil thermal regimes that might occur as a result of past and future non-oil and gas and oil and gas activities in and near NPR-A, potentially leading to synergistic impacts to Special Status Species habitat.

Impacts to Special Status Species habitat may accumulate from the following sources: past non-oil/gas activities, non-oil/gas activities from now until about 2100, past oil/gas activities outside of the NPR-A, future conventional oil/gas activities onshore and offshore of the North Slope including the NPR-A, future unconventional oil activity east of the NPR-A, construction of a road and pipeline(s) from Umiat to the Dalton Highway, and construction of commercial gas pipelines. All future impacts are additive to the impacts to Special Status Species habitat that have accumulated in the past and persist today, but in the context of the entire North Slope west of the Canning River, these cumulative impacts would be relatively small. Based on impacts to 42,050 acres that could still persist in 2100 (Table 4-40), direct impacts to habitat would occur on 0.1 percent of the North Slope west of the Canning River. This estimate does not take into account the quality of habitat that would be impacted on the North Slope. It is likely that the focus of future oil exploration and development would remain relatively near to the coast, and much gas development will likely occur in the same area. Future gas exploration, however, may be concentrated further south in the foothills. A wide variety of habitat types have variable value to Special Status Species could ultimately be affected.

Special Status Species of Terrestrial Mammals

Two species of terrestrial mammals listed as BLM sensitive species are described in section 3.3.8 (Volume 1). The Alaskan hare has been known to occur in the NPR-A in the past, though there has not been a reported sighting on the North Slope since 1951. The Alaska tiny shrew has never been documented in the NPR-A, though given the foothills habitat of the NPR-A and the difficulty of observing this small rodent, it may occur there.

The types of impacts to these two mammalian species would be the same as those for all other terrestrial mammals; the probability of impacts occurring, though, would be substantially less than for other mammalian species because of the rarity of the hare and shrew. The probability of impacts could be further reduced by surveying for hares or shrews early in the planning stage in areas of suitable habitat proposed for development, and then avoiding any populations of sensitive mammal species.

Even under Alternative D, which assumes the highest level of oil and gas activity, development would be unlikely to affect either of these two species, primarily because it is unlikely that either exists in the NPR-A. This is especially so for the Alaskan hare, since if this relatively large-bodied species occurred in the NPR-A it would most likely have been documented one or more times in the last 60 years. It is more likely that the Alaska tiny shrew has occurred or does occur in the NPR-A without having been documented. If development facilities were constructed in an area containing a population of Alaska tiny shrew, adverse impacts to that population could occur.

Due to the low probability of impacts and the relative ease of mitigating adverse effects, it is unlikely that impacts to any sensitive mammal species would accumulate on BLM managed lands in the NPR-A. These species do not enjoy the same level of protection on state or private (Native corporation) lands, however, so some potential remains for cumulative impacts involving death of individuals caught under heavy equipment and loss of habitat, and may accumulate on state and private lands. This potential is still influenced by the species' rarity, making it unlikely that impacts to one species would accumulate due to disturbance in two or more areas occupied by one of these species.

The rarity of the Alaska tiny shrew on the North Slope may be due at least in part to its habitat requirements being met in limited (both in number and geographic extent) areas. This situation may in turn be related to changes in plant communities that occurred during past periods of substantial climate change. Future climate change may further limit the suitable habitat for this species, and this effect may accumulate with any adverse impacts of oil or gas development. The two combined may have synergistic impacts on the probability for continued existence on the North Slope of this species.

Special Status Species Marine Mammals

The following sections discuss the impacts to Special Status Species:

Bowhead Whale and Ice Seals

Bowhead whales are migratory and do not overwinter in NPR-A waters but may feed in large aggregations of up to hundreds of animals in nearshore waters at certain times and places. Ringed and bearded seals belong to the group known as "ice seals" that share similar characteristics, are highly dependent on sea ice for critical life functions, and whose seasonal distributions and movements are heavily influenced by seasonal ice patterns in Arctic waters. The cumulative effects analysis focuses on the Bering-Chukchi-Beaufort Seas stock of bowheads, and ringed and bearded seals. It includes actions across their respective ranges, but focuses on those within the Chukchi and Beaufort Seas where the animals spend the majority of their time.

Humpback and Fin Whale

There is no clear evidence that the extralimital[5] sightings of humpback whales and fin whales in the Beaufort Sea represent a range shift, but it is known that North Pacific humpback populations are increasing at high rates (Allen and Angliss 2010). Unlike the sections analyzing the direct and indirect impacts of the alternatives, humpback and fin whales are given a separate section in the cumulative effects analysis because the past and present effects that may have affected humpback and fin whales are not the same as those that may have affected bowhead whales. No past and present effects from non-oil and gas and oil and gas development on the Arctic Coastal Plain and in the Beaufort and Chukchi Seas are expected to have accumulated to humpback and fin whales.

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[5] Not typically found within a particular area.

Polar Bear

Polar bears are a threatened species that inhabit the coastal areas of the NPR-A. Sea ice, barrier islands, and denning areas along the Alaska coast have been designated critical habitat for the polar bear. Polar bears may be present along coastal areas of the NPR-A at any time of the year, with pregnant females overwintering in shallow maternal snow dens. Proposed activities with the most potential to affect polar bears in the planning area include oil and gas exploration and development, aircraft and watercraft traffic, winter overland travel, and recreational and research activities. These activities could affect threatened polar bears by 1) causing direct mortality from defense of human life, accidental oil spills, and lethal impacts during research activities; 2) altering polar bear behavior, physiology or movements; or 3) disturbing or destroying snow dens, which could cause impacts to cubs at critical life stages, resulting in mortality.

Pacific Walrus

Walrus are seasonal migrants to the Chukchi Sea, where they utilize both the offshore and coastal environment of a portion of NPR-A.

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Bowhead Whale and Ice Seals. The activities most likely to affect bowhead whales, and ringed and bearded seals are subsistence hunting, ship and aircraft traffic, commercial fishing, discharges into the water, contaminants and disease, dredging and coastal development, and climate change. To date, there have been documented effects of industrial noise resulting in avoidance behaviors (Richardson and Malme, 1993) for bowheads. The bowhead whale population has been growing steadily for several decades despite oil and gas activities in the Beaufort Sea and Chukchi Seas, and other industrial activities such as commercial fishing and shipping throughout the Bering-Chukchi-Beaufort Seas bowhead whale stock's range (George et al. 2004).

Before commercial whaling, there were approximately 50,000 bowhead whales (estimated) in the North Polar Region, and about 20,000 in the Bering-Chukchi-Beaufort seas (Bockstoce and Botkin 1983, Woodby and Botkin 1993). Unregulated commercial whaling continued into the early 1900s, reducing the bowhead whale populations to near the point of extinction.

Bowhead whales have been completely protected from commercial whaling since 1946, although Inuit have hunted "the whale" for centuries. In accordance with International Whaling Commission rules, Alaska and Russian Inuit are legally allowed to hunt an allocated number of bowhead whales each year for nutritional and cultural purposes.

Subsistence whaling continues today. In part a result of whaling quotas, the number of bowhead whales in the Bering-Chukchi-Beaufort Sea stock is estimated to exceed 12,600 and is increasing (Koski et al. 2010, Zeh and Punt 2005). Those in the Okhotsk Sea in far east Russia are in the hundreds. The number of bowhead whales has increased from depressed levels in the early 1900s, and the Bering-Chukchi-Beaufort Seas Stock is approaching or at historic levels (Angliss and Outlaw 2005). However, worldwide the cumulative effects of commercial whaling persists today, circumpolar bowhead whale numbers are still much lower than were thought to have occurred before commercial whaling mainly because the very large North Atlantic stocks do not appear to be recovering.

From 2001 to 2010, Barrow whalers harvested between 16 and 28 bowhead whales each year with an average of approximately 21 whales harvested annually (AEWC records). Over the past decade, the quota for Barrow has been 22 strikes per year, however, unused strikes are often transferred to Barrow from other villages. Nuiqsut whalers have had unsuccessful whaling years in from the period 1972 to 1995. Unsuccessful harvests in Nuiqsut were common in the 1980s, with no whales taken in 1983 to 1985, or 1988; in the 1990s, the only unsuccessful years were 1990 and 1994 (USDOI Minerals Management Service 1996a, U.S. Army Corps of Engineers 1998). Nuiqsut whalers have landed between 1 and 4 whales annually with an average of 3.2 per year for the period 2000 to 2010. Wainwright has harvested whales for millennia. In recent years, they landed about five whales per year. Point Lay was recently admitted to the Alaska Eskimo Whaling Commission and has a quota of one whale per year. They have landed two whales between 2009 and 2011 (Alaska Eskimo Whaling Commission records, Suydam et al. 2010).

Reliable population estimates for ringed and bearded seal population have never been realized. These populations have sustained a subsistence hunt for millennia with no known population level effects to date (Cameron et al. 2010, Kelley et al. 2010). Limited commercial and bounty hunting has also occurred at various times. All commercial hunting ended with the passage of the Marine Mammal Protection Act in 1972.

A recent unusual mortality event (UME) affecting ringed seals is described in Section 3.3.8.4 of Volume 1. In 2011, more than 60 dead and 75 diseased seals were reported (NOAA 2011). As of June 2012, subsistence hunters documented another 40 seals with clinical signs of the disease (NOAA 2012b). The disease has not yet been identified, despite extensive testing, and the mechanisms and underlying causes are unknown, as is the total level of impact.

Ship, barge, and small boat traffic continues through the Beaufort and Chukchi seas to re-supply villages, support research, and for subsistence activities. These activities have likely resulted in disturbance to marine mammals, causing avoidance reactions, possible reductions in foraging success, increased energy expenditure, and potentially injury or mortality, particularly to the large whales (George et al. 1994, Laist et al. 2001). The number of such trips is unknown but ship injuries and possible reduced reproductive output and mortality have not prevented an increasing population trend of bowhead or other whales and do not seem to have affected ringed and bearded seal populations (Angliss and Outlaw 2005).

Commercial fisheries (Angliss and Outlaw 2005) and shipping (George et al. 2004, Angliss and Outlaw 2005) have resulted in injuries and likely death of bowhead whales. Reported numbers per year are low and likely an underestimation because of study limitations and reporting requirements (George et al. 2004, Angliss and Outlaw 2005).

Humpback and Fin Whales. Human activities that are possibly impacting humpback and fin whales in the North Pacific include:

- ship strikes;
- entanglement in fishing gear;
- vessel traffic and oil and gas exploration; and
- whale watching, scientific research, photography, and associated vessel traffic (Perry et al. 1999)

The threat of disease or predation is unknown. Historic commercial whale hunting resulted in the depletion and endangerment of humpback and fin whales. However, trend analysis of surveys indicates that both North Pacific fin and humpback whale populations are increasing (Allen and Angliss 2010). No subsistence take of humpback or fin whales is reported from Alaska or Russia.

Entrapment and entanglement in active fishing gear is the most frequently identified source of human caused injury or mortality to humpback whales and it has been documented to have occurred in Alaska (Gabriel et al. 2007). Entrapment and entanglement continue, both in waters off Alaska and other areas (Angliss and Outlaw 2005); however, there are no records of entrapment in the Chukchi Sea, likely due to very limited fishing in the Chukchi and because the southern margin of the Chukchi Sea is generally considered to be the northern margin of the humpbacks range. No data are available regarding fin whale entanglement in fishing gear.

Perry et al. (1999) summarized that humpbacks respond to moving sound sources (e.g., fishing vessels, low-flying aircraft) and the long-term displacement of humpbacks from Glacier Bay and parts of Hawaii may have occurred due to vessel-noise disturbance. Noise on their wintering grounds from the Acoustic Thermometry of Ocean Climate and the Navy's Low-Frequency Active Sonar program also are sources of concern for the central North Pacific stock (Angliss and Lodge 2002). The National Marine Fisheries Service (National Marine Fisheries Service 1991) also lists noise and disturbance from whale-watching boats, industrial activities, and ships, boats, and aircraft as causes of concern for humpback whales. No data are available regarding fin whale responses to anthropogenic noise.

Vessel collision also is of concern. The National Marine Fisheries Service (1991) reported that at least five photographed humpbacks in southeastern Alaska had gashes and dents probably caused by vessel strikes. Vessel strikes have caused humpback mortalities in the California/Oregon/Washington stock (an average of 0.4 per year, 2004-2008; Carretta et al. 2011), the Central North Pacific stock (0.2 per year, 2003-2007; Allen and Angliss 2011), and in the northwestern Atlantic (Perry et al. 1999). Although ship strike mortality and serious injury of fin whales in the California/Oregon/Washington stock averaged 1.0 per year for 2004-2008 (Carretta et al. 2011), there are no reports of direct human-related injuries or mortalities to fin whales in Alaska waters (Allen and Angliss 2011).

Perry et al. (1999) reported that continued development of coasts and oil exploration and drilling may lead to humpbacks avoidance of areas. In a Newfoundland inlet, two humpbacks with severe mechanical damage to their ears were found dead near a site of continued subbottom blasting (Ketten et al. 1993, Ketten 1995). The impacts of pollution and habitat degradation due to coastal development are not known. In Hawaii, harbor and boat-ramp construction, vessel moorings, water sports, increased boat traffic, dumping of raw sewage by boats, runoff and overflow of sewage from land sites, and agriculture and associated runoff are all potential causes of current humpback whale habitat degradation.

Polar Bear. The following non-oil and gas activities could contribute to potential cumulative effects on polar bears: harvest, other sources of direct mortality, research, pollution and contaminants, and coastal development.

Alaska Harvest: Historically polar bears have been killed for subsistence, handicrafts, and recreation by non-Native hunters. Hunting by non-Natives has been prohibited since 1973 when provisions of the Marine Mammal Protection Act (MMPA) went into effect, reducing the mean annual statewide harvest of both the Southern Beaufort Sea and Chukchi/Bering Sea populations (U.S. Fish and Wildlife Service 2010a and b), while allowing Alaska Natives living in coastal communities to hunt polar bears for subsistence and the making of handicrafts. The Southern Beaufort Sea population is currently considered depleted (U.S. Fish and Wildlife Service 2010b), and harvest quotas are set by the Inuvialuit-Inupiaq Council. The harvest level for the Chukchi/Bering Sea population is not limited at this time; and while the Alaska Native harvest from this population is reported to have declined recently, the portion of harvest that occurs in Russia is not well quantified (U.S. Fish and Wildlife Service 2010a).

Other Sources of Direct Mortality: Polar bears are occasionally killed during defense of life and property (Brower et al. 2002). Other relatively rare sources of mortality include predation by other polar bears, injury during fights or attacks among polar bears for reproductive advantage (Swenson et al. 1997), and injury received during play bouts (Taylor et al. 1985). Polar bears may also occasionally sustain serious injury while hunting, which can lead to death (Stirling et al. 2008).

Research Activities: There are several on-going research programs studying polar bears on the North Slope. Certain research techniques may require capture and handling of polar bears, including sublethal measurements and tissue sampling and tagging and marking bears. Other research activities involve locating or counting polar bears from low-flying aircraft while the bears are at or near coastal locations. The long-term goal of these research programs is to gain information on the ecology and population dynamics of polar bears to inform management decisions. These research activities may cause short-term adverse effects to individual polar bears observed in surveys or targeted in capture efforts and may also incidentally disturb other bears nearby. Polar bear research is authorized through permits issued under the Marine Mammal Protection Act; and research plans must minimize the potential risk of incidental disturbance, injury, and death of bears.

Contaminants: Schliebe et al. (2006) provide a comprehensive review of contaminants and the potential biological effects they may have on polar bears. Petroleum hydrocarbons, persistent organic pollutants, and heavy metals are thought to be the three main types of contaminants that pose the greatest risks to polar bears. Each of these types of contaminants come from a variety of sources and tend to persist in the environment.

Petroleum hydrocarbons in the local environment could come from natural seeps, from unremediated fuel or oil spills from marine vessels or aircraft, or from camps located near the marine environment. The impacts to polar bears that may be caused by these isolated types of releases are discussed in Chapter 4 (see 4.3.11.4). Persistent organic pollutants come from the historic and current global use of persistent pesticides that have entered the marine food chain and tend to bio-accumulate in top predators, including polar bears. Coal-fired power plants around the world are a source of heavy metal pollution that enters the marine environment through long-distance dispersal of particulates. Persistent organic pollutants and the heavy metal mercury are known to have accumulated in individuals of the Southern Beaufort Sea and Chukchi/Bering Sea populations of polar bears, although adverse impacts have not been demonstrated for individual bears nor are the contaminants thought to have population-level effects. However, contaminant body burdens, in combination with other factors such as loss of sea ice habitat and decreased prey availability, could ultimately contribute to adverse effects in the health or productivity of individual polar bears.

Coastal Development: The BLM estimates that approximately 1,800 acres have been occupied by community development in six Alaska North Slope villages through 2008, with much of the development associated with these villages occurring along the coast. Fourteen Distant Early Warning-Line sites were constructed along the coast of the North Slope in the 1950s, ranging in size from 150 to 2,835 acres. Beginning in the 1990s some of these sites have been remediated and restored, while others were converted to National Weather Service stations.

Because polar bear dens may be found on land, the coastal development that has occurred, and its associated disturbance, have likely removed or made unavailable some polar bear denning habitat. Given the relatively small footprint of coastal development, and the small proportion of polar bears that have historically denned on land, this has likely had no effect on polar bears at the population level. Coastal development since 1900 has likely increased disturbance effects to bears and increased human-bear encounters, but there is no evidence that this has significantly affected polar bear populations. If land-based denning by polar bears increases with declines in sea ice, future coastal development may make potential polar bear denning habitat prone to disturbance or unavailable.

Pacific Walrus. The following non-oil and gas activities could contribute to potential cumulative effects on walrus: commercial and noncommercial harvest, predation, contaminants and disease, scientific research, commercial shipping and icebreaking, and commercial fishing.

Commercial Harvest: Large-scale commercial harvests are thought to have reduced Pacific walrus from a pre-exploitation population of about 200,000 animals to between 50,000 and 100,000 animals in the mid-1950s (Fay et al. 1997). The population apparently increased rapidly in size during the 1960s and 1970s in response to harvest regulations that limited the take of females (Fay et al. 1989). Commercial harvest of marine mammals in the U.S. is currently prohibited by the

MMPA and was last conducted in Russia in 1991. Commercial harvest is no longer considered a threat to Pacific walrus, now or in the foreseeable future (76 FR 7634, February 2011).

Combined U.S. and Russia Noncommercial Harvest: The U.S. Fish and Wildlife Service uses the average annual harvest over the past five years as the representative estimate of current harvest levels in the U.S. and Russia. The estimated harvest of Pacific walrus from 2003-2007 is 4,960-5,457 walrus per year (U.S. Fish and Wildlife Service 2010). The Pacific walrus population is classified as strategic under the MMPA, and the population is a candidate for listing as threatened or endangered under the ESA. However, subsistence hunting of marine mammals is protected under the MMPA, such that commercial or government activities do not have unmitigatable effects on the availability of marine mammals for subsistence hunters. Subsistence hunters use boats and snowmachines for access, which could contribute to cumulative effects to walrus through noise and disturbance.

Predation: Because of their large size and formidable tusks, adult walrus have few natural predators. Polar bear and killer whales tend to prey on walrus opportunistically and focus primarily on young animals. When walrus haul out on land they become vulnerable to terrestrial predators

Contaminants and Disease: Available information indicates that Pacific walrus have relatively low concentrations of contaminants of concern (Robards 2006, Robards et al. 2009). Although persistent organic compounds and metal pollutants from many global sources are of particular concern in the Arctic, these contaminants are found in Pacific walrus at relatively low concentrations (Seagars and Garlich-Miller 2001, Taylor et al. 1989), presumably because walrus tend to feed lower on the food chain than other marine mammals. There is currently no evidence of population-level effects in walrus from contaminants of any type (76 FR 7634, February 10, 2011).

Although known to be susceptible to certain diseases and host to several kinds of parasites, disease incidence is not particularly high in walrus. However, it may increase with less ice availability and more restricted distribution of walrus (Jay et al. 2011), or with the introduction of new organisms in the changing Arctic marine environment. During 2011 some walrus and ice seals with unusual skin lesions were reported starting in July on the Arctic coast of Alaska, with most reports coming from the geographic area spanning Barrow to Wainwright. Some cases were also reported in Russia and Canada. In September 2011, there were reports of skin lesions in some walrus hauled out at Point Lay, with some mortalities reported. The potential causes of the lesions and mortalities are under investigation, but preliminary findings have not yet revealed a definitive cause of this Arctic disease outbreak, and it is not known if the sores in walrus are related to those seen in seals (National Oceanic and Atmospheric Administration 2011).

Scientific Research: A large number of scientific research programs occur on the North Slope and in the nearshore and offshore areas of the Chukchi Sea. Much of the field research occurs during summer when walrus are present. Research activities involve use of vessels, aircraft and over ice vehicles, which may contribute to cumulative effects through disturbance of walrus.

Commercial Shipping and Ice Breaking: Commercial shipping in the Arctic is increasing as sea ice diminishes, and several cargo ships have transited the new Northern Sea route. Icebreaking activities along the Alaska Coast are minimal at this time and usually carried out by the Coast Guard. Icebreaking activities often occur in the summer months and can create noises that cause marine mammals to avoid areas immediately near icebreaking activities, although walrus have been found concentrating in and around temporary breaks in the ice created by icebreakers. Noises associated with shipping and icebreaking, and possible oil spills, could contribute to cumulative effects on walrus.

To date there have been relatively few oil spills caused by marine vessel traffic in the Bering and Chukchi seas. Within the seasonal range of the walrus, there were approximately six vessel oil spills between 1995 and 2004 (76 FR 7634, February 10, 2011). The incidents were small in scale and did not cause widespread impacts to walrus or their habitat.

Commercial Fishing: Overall nine fisheries operate in Alaska within the range of the Pacific walrus in the Bering Sea. Walrus occasionally interact with trawl and longline gear of groundfish fisheries, but fishery-related mortality is considered insignificant (U.S. Fish and Wildlife Service 2010). Commercial fishing north of the Bering Strait is currently closed. However, ecosystem shifts in the Bering Sea are expected to extend the distribution of fish populations northward, and along with this shift, nonpelagic bottom trawl fisheries are expected to move northward (NOAA 2009). Commercial fisheries have the potential to contribute to cumulative effects on walrus through noise, possible discharges or oil spills, and possible depletion of prey through modification of benthic habitat.

Oil and Gas Exploration and Development Activities

Bowhead Whale and Ice Seals

Seismic Surveys, Exploration, and Disturbance: Seismic surveys offshore in the Beaufort or Chukchi Seas began in the late 1960s, peaking in the late 1980s. Prior to 2006, the last Minerals Management Service permitted seismic in the Beaufort Outer Continental Shelf was in 2004, and 1990 in the Chukchi (USDOI Minerals Management Service 2006b). Approximately 100,000 miles of 2D and 3D seismic has been collected in the Beaufort and approximately 80,000 miles of 2D in the Chukchi. These estimates are a combination of over-ice and open-water seismic (USDOI Minerals Management Service 2006f). The Minerals Management Service predicted up to 4 surveys in the Beaufort and 4 in the Chukchi, but only 3 surveys were conducted in the Chukchi and one in the Beaufort (USDOI Minerals Management Service 2007b). While historic seismic work likely displaced bowheads, ringed, and bearded seals and resulted in avoidance behavior, no data are available to assess population level effects to these species.

Marine seismic exploration produces the loudest industrial noise in the bowhead whale and ice seal habitats. Some seismic surveys have been conducted in winter and spring on the sea ice, but most are done in the summer-autumn open-water period. Thus, bowhead whales, seals, and seismic vessels were at times in the same areas, including during the westward fall migration of whales. In the nearshore Alaskan Beaufort Sea, nearly all the fall-migrating bowhead whales avoided an area within 12 miles (20 km) of an operating vessel, and deflection of the whales began at up to 21 miles (35 km) from the vessel (Richardson 1997, 1998, 1999; National Marine Fisheries Service 2002). Noise levels received by these whales at 12 miles were ~117 to 135 dB re: 1 µPa (National Marine Fisheries Service 2002). Feeding whales appear more tolerant of seismic sound than do migrating whales. During surveys in the Central Beaufort Sea in 2007-2008, feeding bowheads appeared to tolerate seismic sounds up to noise levels approaching ~160dB; some tolerated higher levels. This is much higher than the 120-130dB threshold for avoidance by migrating bowheads observed during seismic operations in the same area during the late-1990s (Koski et al. 2009).

Offshore exploratory drilling in the Beaufort also resulted in the deflection of fall migrating bowhead whales. Bowheads were detected changing direction at between 12 and 19 miles (20 to 32 km) from drilling platforms (Brewer et al. 1993, Davies 1997, Hall et al. 1994). Drilling ships appear to cause similar avoidance behavior (LGL and Greeneridge 1987). Unlike bowheads, seals show little reaction to seismic exploration activities as noted in section 4.3.10 (Volume 2).

Construction of Northstar, Endicott, and other artificial islands occurred mostly in shallow water areas not regularly used by bowhead whales. However, activity at Northstar resulted in deflections of bowheads, particularly when barges were maneuvering (Richardson and Williams 2005). Observed seals showed little indication of disturbance during construction activity as noted in section 4.3.10 and 4.3.11 (Volume 2).

Oil Spills: A number of small oil spills have occurred during oil and gas exploration in the Alaskan Beaufort Sea in past years. Only five spills have been greater than one barrel, and the total spill volume from drilling 52 exploration wells (1982 through 1991) was 45 barrels (USDOI Minerals Management Service 2006f). None of these spills are known to have affected bowhead whales or ice seals.

Humpback and Fin Whales

Seismic Surveys, Exploration, and Disturbance: Oil and gas activities in other areas may have impacted humpback whales. Studies have documented that humpback whales, especially females with calves, respond to seismic survey noise and Todd et al. (1996) concluded that exposure of the humpbacks to deleterious levels of sound may influence entanglement rates. Information to assess whether these accumulate and affect the population is lacking.

Polar Bear

Activities associated with the oil and gas industry have the potential to impact polar bears and their habitat. Oil and gas-related activities have occurred on the North Slope since the early 1900s, with the majority of infrastructure constructed during the 1970s and early 1980s and ongoing oil production for more than 30 years. Activities that have taken place with the potential to impact polar bears include exploration and development, aircraft and watercraft traffic, and winter overland travel. These activities could have affected polar bears by causing direct mortality from defense of human life and property, accidental oil spills, altered polar bear behavior or movements, disturbance to denning females or destruction of snow dens (which could cause impacts to cubs at critical life stages), and disturbance of foraging bears that may result in energetic costs.

For a portion of this time, oil and gas activities have been regulated by Incidental Take Regulations (ITRs) under the Marine Mammals Protection Act, which are designed to avoid and minimize potential impacts of the oil and gas industry's activities on polar bears. Incidental Take Regulations for the oil and gas activities in the Beaufort Sea have been issued since 1993; Incidental Take Regulations have also been issued for oil and gas industry activities in the Chukchi Sea during 1991-1996, and from 2008 through the present. In addition to prescribing protections for polar bears during oil and gas activities, the ITRs require operators to report the number of polar bears observed, their response to oil and gas activities, and whether any bear deterrence actions were required.

Direct mortality of polar bears related to oil and gas activities in Alaska have been very rare. Prior to the issuance of Incidental Take Regulations, there were two documented instances of polar bears killed in defense of human life, in association with oil and gas activities (Schliebe et al. 2006). Since the issuance of Incidental Take Regulations, one documented polar bear mortality occurred in the summer of 2011, when a female polar bear was accidently killed during a deterrence attempt by security personnel at a North Slope oil field facility.

Seismic Activity and Exploration: Onshore and offshore seismic activity has occurred within the ranges of the Southern Beaufort Sea and Chukchi/Bering Sea polar bear populations for decades. It is likely that past and present seismic and exploration activities have resulted in numerous types and instances of disturbances, including those caused by aircraft, vehicular, pedestrian, and vessel traffic, construction and drilling activities, and noise and activity at facilities. The impacts that may have been caused by these activities are generally similar to those discussed in Volume 2, Chapter 4 (4.3.11.4).

For most of the year, polar bears are not very sensitive to noise or other human disturbances (Amstrup 1993). However pregnant females and those with cubs in dens (both on land and sea ice), are sensitive to noise and vehicular traffic (Amstrup and Gardener 1994); so seismic and other exploration activities have potential to impact individual bears, particularly denning females. There has been a documented instance of past North Slope seismic exploration disturbing a bear in a maternity den (U.S. Fish and Wildlife Service1986). In other instances polar bears have initiated dens among oil field infrastructure. Dens have been found on the embankments of large gravel pads. In May 2011 a female and two cubs emerged from a previously undetected den near an oil field ice road, and a den was also found on Spy Island in 2011 (Craig Perham, U.S. Fish and Wildlife Service personnel communication).

The Beaufort and Chukchi Incidental Take Regulations require industry to coordinate with the U.S. Fish and Wildlife Service to avoid disturbance to polar bear dens by one mile, and may require a search for potential polar bear dens prior to any seismic activity or exploration with potential to disturb denning polar bears. The oil and gas industry reported no polar bear observations during seismic activities conducted during 2006-2011 (U.S. Fish and Wildlife Service 2011). Because seismic and exploration activities are required to occur at a physical distance that protects denning polar bears from disturbance, these activities are not thought to present a risk to polar bears.

Oil and Gas Development and Production: Oil and gas development across the North Slope has resulted in approximately 17,000 acres of tundra converted to gravel or gravel mines during the period 1968 to 2001. Several artificial offshore islands have also been constructed, as well as two gravel causeways (West Dock and Endicott). The impacts that may have been caused by oil and gas development are generally similar to those discussed in Volume 2, Chapter 4 (4.3.11.4). Oil and gas activities may result in disturbance to individual polar bears and may prevent some polar bears from using small portions of habitat. In particular, some polar bear denning habitat has likely been altered or made unavailable as a result of construction and human activity. The amount and effect is unknown but likely minimal, since the majority of historic dens were offshore and most land dens were to the east of major development (Amstrup and Gardner 1994). The main land-based polar bear travel corridor (within one mile of the coast) and nearshore area has been fragmented to some extent; but the effect has likely again been minimal, given the small amount of development related to total area and the ability of polar bears to cross man-made routes, including roads and causeways.

Reports from the Beaufort Sea oil and gas industry for 2006-2009 show that, on average, 306 polar bears are observed by industry each year. Eighty-one percent of the 1,414 bears observed during this time showed no change in their behavior, four percent altered their behavior by moving away from (or toward) the industrial activity, and the remaining 15 percent were subject to intentional hazing or other deterrence actions for the safety of humans and the bears. The majority of interactions involved only minor and temporary changes in bear behavior (U.S. Fish and Wildlife Service 2011), with the exception of the single polar bear accidently killed in 2011 during a deterrence attempt by oil field security.

The Marine Mammal Protection Act and Endangered Species Act restrictions, and resulting coordination between the industry and U.S. Fish and Wildlife Service, have played a large role in active avoidance and minimization of impacts to polar bears. Whereas industry activities have had some effects on individual polar bears, there is no evidence these effects have resulted in changes to polar bear populations (U.S. Fish and Wildlife Service 2007).

Oil Spills: The National Research Council's Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (2003) found that most spills to date have had only local effects, and that there is no evidence that effects of spills have accumulated. Spills onshore have been relatively common but generally small (NRC 2003), and offshore spills have been less common and smaller (USDOI Minerals Management Service 2006d). No spill has been associated with adverse effects on Southern Beaufort Sea or Chukchi/Bering Sea polar bears (Schliebe et al. 2006).

Solid and liquid hazardous materials associated with oil and gas industry activities have been discarded or dumped at various locations on the North Slope, including the NPR-A. Many of these sites have been cleaned up, but low levels of hydrocarbons remain at some sites. These localized sites probably do not represent a substantial threat to polar bears, but the potential to impact bears likely still persists. Impacts from hazardous wastes are discussed above in relation to non-oil and gas activities.

Oil and gas development in the Chukchi and Beaufort Seas has the greatest potential to lead to additive effects for polar bears and could include direct fouling of polar bears, their prey, or their habitat. Even small spills that could not be completely remediated could accumulate over time. These spills could foul ice and shorelines, so the continued risk of direct exposure remains, as does the risk of long-term contamination of both marine and terrestrial habitats.

Pacific Walrus

Oil and gas related activities have been conducted in the Beaufort and Chukchi Seas since the late 1960s, with most activity occurring in the Beaufort Sea. Exploration activities are currently regulated under the Marine Mammal Protection Act, with non-lethal incidental take of walrus only authorized when activities are considered likely to result only in the disturbance of small numbers of walrus, with a negligible impact on the population. Specific studies on the effects of exploratory drilling activities and associated shipping and seismic surveys have documented minimal effects to walrus—namely, transitory behavioral changes that were temporary in nature (76 FR 7634, February 12, 2011). To date, no cumulative effects of oil and gas exploration activities have been demonstrated on walrus in the Beaufort or Chukchi Seas.

Summary of Past and Present Effects and Their Accumulation

Bowhead Whale and Ice Seals

For Bering-Chukchi-Beaufort seas bowhead whales, the most dramatic population level impacts were associated with commercial whaling that occurred from 1849 to 1915 (Bockstoce and Botkin, 1983). In fact, all circumpolar bowhead populations are still recovering to varying degrees from commercial whaling today (Zeh et al. 1993).

More recently, climate change and increasing human activities (particularly with regard to oil and gas activities) may be having large impacts on these species. For bowheads, some information is available on how individual animals respond to oil and gas activities but the observations are short-term and provide little usable data for longer-term effects on individuals or the population. Bowheads seem to be highly sensitive to low levels of anthropogenic sounds and deflect away from those sounds or change their behavior. Ringed seals seem to be quite tolerant of anthropogenic activities. Little is known about other species.

Although some information exists on how individual animals respond to anthropogenic sounds, it is not known how those effects accumulate. Most bowhead whales annually return to Beaufort Sea to feed, and much information exists on how individual animals respond to anthropogenic sounds (Richardson et al. 1995). One such response is that migrating bowhead whales have avoided areas of specific human activities ranging from a 1-2 km to over 20 km (Richardson 2008) to well over 20 km (Richardson 1999). Bering-Chukchi-Beaufort seas bowheads do not seem to have habituated to industrial activities. If effects were countervailing or do not accumulate over years, cumulative effects or past and present activities may have been minimal to date.

Hunting and commercial fishing are the two primary factors that have affected bowhead whales in the past and continue today while ringed and bearded seals are thought to have been relatively unaffected yet by anthropogenic sources. Commercial fishing and vessel strikes have resulted in injury and some mortality for bowheads (Angliss and Outlaw 2005, George et al. 1994). Subsistence take has been below the Potential Biological Removal threshold determined by NOAA-Fisheries and the allowable harvest under International Whaling Commission standards (Angliss and Outlaw 2005, Allen and Angliss 2010). While the above activities have removed individuals from the bowhead population and possibly affected population growth rates, the impact is minimal and has not altered a strong population growth trend (George et al. 2004).

Noise and disturbance associated with offshore seismic and drilling activities, and boat and barge traffic have affected bowhead whales, causing deflection and behavioral changes. (Richardson et al. 1995). A large body of literature exists about the sensitivity of bowhead whales to industrial sounds and activities (see National Research Council, 2003); however, it is not known how effects from these stressors accumulate. Bowhead populations have been increasing for at least three decades despite oil and gas activities. It is possible, though, that the population could have increased more rapidly in the absence of industrial activities. It appears that ringed and bearded seals are relatively insensitive to some disturbance impacts from oil and gas activities such as vessel traffic, offshore seismic, drilling activities but studies have not been completed to assess with confidence whether long-term persistent changes in behavior exist that could lead to reduced fitness and population changes. Other impacts from oil and gas activities such as vessel discharge, introduction of new biota, oil spills, and changes in prey distribution or abundance have a high probability of negatively impacting seals.

Humpback and Fin Whale

Commercial fishing, whale watching in Southeast Alaska, and ship-traffic have been and continue to be the primary activities that affect humpback and likely fin whales since cessation of commercial whaling. The estimated mortality of humpbacks from human activity remains below the Potential Biological Removal threshold but likely great enough to have effects on the populations (Angliss and Outlaw 2010).

Polar Bear

Prior to the 20th century, both the Chukchi/Bering and Southern Beaufort Sea polar bear populations probably existed near carrying capacity (U.S. Fish and Wildlife Service 2010a). Once harvest by non-Natives became common in the 1960s, the size of the Southern Beaufort Sea population declined substantially (Amstrup et al. 1986, Amstrup 1995). Since passage of the Marine Mammal Protection Act in 1972, both the southern Beaufort and Chukchi/Bering sea populations seem to have increased (U.S. Fish and Wildlife Service 2010). However, polar bears have since been listed as threatened range-wide because of climate change-related threats to the species' sea ice habitat.

Changes in sea ice conditions can have cascading effects that increase the magnitude of effects from other sources of impact. For example, thinning ice and a greater extent of marginal ice stability in the fall may already be leading to reduced sea ice denning, and a corresponding increase in denning on land, in Southern Beaufort Sea bears (Fishbach et al. 2007). This in turn increases the probability of disturbance to denning bears from human activities. The chances of bear-human encounters in coastal villages and industrial areas also increases with a greater proportion of the Southern Beaufort Sea or Chukchi/Bering Sea populations coming on land during the fall open-water period, or as the amount of time individual bears spend on land increases.

Pacific Walrus

The size of the Pacific walrus population has never been known with certainty, and has undergone marked fluctuations in response to varying levels of human exploitation. Large-scale commercial harvests reduced the population to an estimated 50,000-100,000 animals in the mid-1950s. The population is believed to have increased in size during the 1960s and 1970s in response to reductions in hunting pressure, and the current population estimate is 129,000 animals. Besides sustainable subsistence hunting, few other activities have had effects on walrus in their summer range in the Alaska Chukchi Sea.

However, due to recent concerns about the loss of seasonal sea ice habitat in the Chukchi Sea, the Pacific walrus population is now a candidate for listing as a threatened or endangered species. In response to the nearly complete absence of sea ice in the Chukchi Sea during recent summers, walrus have begun to haul out in large numbers on portions of NPR-A's Chukchi coastline. Walrus aggregated at haulouts are particularly sensitive to disturbance and may stampede toward the water, potentially injuring or killing large numbers of juveniles.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Bowhead Whale and Ice Seals

Non-oil and gas activities could also contribute to cumulative effects on bowhead whales, ringed, and bearded seals. Principle effects include: shipping, commercial fishing, subsistence hunting, tourism, and climate change. A presumably small number of bowhead whales could be injured or killed as a result of entanglement in fishing gear or collisions with ships most likely in the Bering Sea (Reeves et al. 2012). Fishing would compete for seal prey items and over time may produce population level effects due to decreased body conditions of seals from nutritional stress. It is expected that subsistence harvesters from Alaska and Russia would continue to harvest bowhead whales under a quota authorized by the International Whaling Commission and that currently unregulated traditional seal harvest will continue as well. The subsistence harvest of whales is carefully managed to prevent population level effects, and to allow the Bering-Chukchi-Beaufort seas bowhead whale population to continue to grow, and seal harvest levels are not believed to have any effect on population sizes. Although a few individuals would likely be injured or killed, non-oil and gas activities are not expected to have much impact on the bowhead whale or seal populations, and bowhead whale populations have increased steadily under current management (George et al. 2004, Zeh and Punt 2005). However, if major commercial shipping routes become established in the Arctic, ship strikes of bowheads and other shipping related effects may occur at higher rates (e.g., oil spills, debris, bilge water) (Reeves et al. 2012).

Past and present activities associated with hard rock mining, operation and rehabilitation of Distant Early Warning-Line and similar military sites, tourism, and scientific research can cause effects to bowhead whales, ringed, and bearded seals and result in disturbance, deflections, and masking of whale and seal sounds. These disturbances can be expected to continue or possibly increase in the future.

It is likely that reduced sea ice in the Beaufort and Chukchi Seas will continue to result in increased commercial shipping traffic and possibly in increased commercial fishing. These activities could result in an increase in vessel collisions for bowheads resulting in additional injury and mortality. The magnitude of this impact would be dependent on the number of vessels, their type, their routes, speed, and timing of travel relative to the presence of whales (Reeves et al. 2012).

Climate changes in the marine environment are resulting in shifts northward of important commercial fish species. It is likely that the fishing industry will at some point follow. Increased fishing effort in areas currently used by bowheads and ice seals would likely result in an increased rate of encounters with fishing gear, greater entanglement rates and subsequent injury, loss of fitness, and mortality. Ringed and bearded seals would experience an increased competition for food resources, which could affect overall body condition and recruitment into the population.

Humpback and Fin Whale

Future effects to humpback and fin whales would be similar to those as described for bowhead whales in section 4.8.7.11 if humpback and fin whales extend their ranges into the Chukchi and Beaufort Seas.

Polar Bear

The primary concern for polar bears on the North Slope is loss of sea ice. The potential for an oil spill remains a potential threat to polar bears at the local population level, and this threat may increase with increased shipping traffic in the Arctic. While most other threats discussed above are either being managed or are not currently thought to be significant threats to polar bear populations, each could become significant in combination with future effects of climate change and the resultant loss of sea ice.

Pacific Walrus

Predation: If sea ice continues to disappear during the summer off Alaska's Chukchi Sea shorelines, it is anticipated there will be more interactions between walrus and polar bears that have come onto land. As a result it can be anticipated that walrus will be forced to move to another location in an attempt to get away from the bears. Walrus would be at increased risk of predation by polar bears, displacement from preferred foraging areas, and the energetic costs of attempting to move away from polar bears.

Disease: Although currently only seen in a relatively small number of individual walrus, it is possible that emerging diseases, like the skin lesions, could become more common and result in outbreaks at walrus aggregations. An increase in walrus disease will contribute to cumulative effects through reduced fitness or unusual mortality events.

Scientific Research: Interest in research in the Arctic is increasing, and the decline in sea ice is making the Arctic marine environment available in expanded ways. Research activities involve use of vessels, aircraft and over ice vehicles, which may contribute to cumulative effects through disturbance of walrus.

Commercial Shipping and Icebreaking: Commercial shipping and icebreaking is expected to increase in the Chukchi and Beaufort Seas. Privately contracted icebreaker use could increase to assist commercial shipping and marine transportation. Increased commercial shipping and icebreaking activities will increase the potential for noise and may increase risk of oil spills by increasing vessel traffic in ice-filled waters. Increases in these activities can contribute to cumulative effects on walrus through disturbance from noise and potential oil spills.

Commercial Fishing: Ecosystem shifts in the Bering Sea are expected to expand the distribution of fish populations northward and, along with this shift, non-pelagic bottom trawl fisheries are also expected to move northward (NOAA 2009). An expansion of commercial fisheries into the Chukchi Sea would have the potential to contribute to cumulative effects on walrus through some additional vessel noise, possible discharges or fuel spills, and possible depletion of prey through modification of benthic habitat.

Oil and Gas Exploration and Development Activities

Bowhead Whale and Ice Seals

Noise and Disturbance: Bowhead whales, ringed, and bearded seals could be exposed to increased disturbance as a result of exploration and development of existing leases or leases acquired in future sales, including leases in the Outer Continental Shelf and State waters. As with other marine mammals, it is not known if a threshold exists relative to the number of disturbance events per year or the number of disturbance events among years that would result in long-term changes in movement patterns, including shifts in foraging behavior and den sites, or in access to productive forage areas.

Development within the NPR-A, elsewhere on the North Slope, in the Canadian Beaufort Sea, in the eastern Russian Arctic, and in adjacent offshore areas, would result in increases in vessel traffic, particularly barge traffic to staging areas, operations bases and camps, drill sites, and onshore infrastructure. Such increases would result in a greater likelihood for disturbance to bowhead whales especially should barge traffic coincide with the fall migration of bowhead whales from Canadian waters to the Bering Sea.

Oil Spills: If a large oil spill were to occur as a result of (1) development and production associated with any past, present, or reasonably foreseeable future development project on the North Slope or in the Beaufort or Chukchi seas, or (2) grounding of a large commercial vessel, some bowhead whales, ringed, and bearded seals would likely be impacted. However, most whales directly exposed to spilled oil would likely experience temporary, nonlethal effects from skin contact with oil, inhalation of hydrocarbon vapors, ingestion of oil-contaminated prey, baleen fouling, reduction in food resources, or temporary displacement from some feeding areas (National Research Council 2003). A few individuals could be killed if they were to experience prolonged exposure to freshly-spilled oil. Reproductive effects are also possible. Effects to seal species would depend on a number of factors such as the amount and duration of exposure, and proportion of oiled prey consumed. After the Exxon-Valdez Oil spill in 1989, Exxon (2010) reported significant numbers of harbor seals were affected by oiling and succumbed to its effects. Hoover-Miller et al. (2001) contend these effects were overstated, and that seal mortality was indistinguishable from natural population declines. Reduction in food resources would be more detrimental to seal species due to their life history characteristics when compared to long-lived bowhead whales with large stored energy supplies. Oil spill clean-up activities (e.g., vessel and aircraft traffic) could displace some bowhead whales, should those activities coincide with the fall migration.

Humpback and Fin Whale

Future effects to humpback and fin whales would be similar to those as described for bowhead whales in section 4.8.7.10 if humpback and fin whales extend their ranges into the Chukchi and Beaufort Seas.

Polar Bear

The U.S. Fish and Wildlife Service works to monitor and mitigate potential impacts of oil and gas activities on polar bears through regulations under the Marine Mammal Protection Act and the Endangered Species Act. Activities operating under these regulations must adopt measures to ensure the total taking of polar bears remains negligible and minimizes impacts to their habitat. Therefore future effects associated with oil and gas activities, including all of those described in section 4.8.3.2 will, by regulation, remain negligible to polar bears and their habitats. The possibility of a large oil spill is thought to be the largest potential threat to polar bears as a result of oil and gas activities (U.S. Fish and Wildlife Service 2011).

Pacific Walrus

Oil and gas activities are expected to increase in the Beaufort and Chukchi Seas. Future oil and gas activities are expected to be regulated in a similar manner to present oil and gas activities, with protections for walrus under provisions of the Marine Mammal Protection Act. Therefore, impacts of oil and gas exploration and development that are likely to occur over the foreseeable future will have minimal, non-cumulative effects on walrus.

Expanding oil and gas activities in the Chukchi Sea increases the chance of an oil spill in the marine environment inhabited by walrus. Because walrus are seasonally abundant in the Chukchi Sea, an oil spill could cause direct mortality to a large number of animals, reduction in the walrus prey base, and the potential for disturbance and displacement from important foraging areas due to hazing or response activities. These activities could contribute to the cumulative effects to walrus due to disturbance, displacement, injury, or mortality.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Bowhead Whale and Ice Seals

Impacts to bowhead whales, ringed, and bearded seals from development within the NPR-A would generally be similar to those discussed for other marine mammals. Increased projected levels of industrial operations associated with the development scenarios of the IAP/EIS alternatives would contribute correspondingly to additional barge, other vessel, and aircraft related impacts.

Humpback and Fin Whale

Future effects to humpback and fin whales would be similar to those as described for bowhead whales in section 4.8.7.10 if humpback and fin whales extend their ranges into the Chukchi and Beaufort Seas.

Polar Bear

Impacts to polar bears would generally be similar under all the alternatives proposed for the NPR-A. Oil and gas activities, with respect to impacts to polar bears, would be regulated under the Marine Mammal Protection Act and the Endangered Species Act, and limited to causing negligible impacts to the species.

The risk posed by a large oil spill is the exception because this is the only activity that changes between the alternatives that has the potential to have a local population level effect on polar bears. The overall potential for a spill would be expected to increase with increasing levels of exploration and development on- and off-shore on the North Slope. Thus, risks to polar bears from a spill would be greatest under Alternative D, similar under Alternatives A and C, and least under Alternatives B-1 and B-2.

Pacific Walrus

If offshore oil and gas development infrastructure with potential for noise and visual disturbance occurred at or near preferred walrus haulout locations on the Chukchi coast, its presence could cause frequent disturbance of walrus and possibly stampede-related mortality events. Potential cumulative effects to walrus would be minimized to greater degrees under certain alternatives.

Under Alternative A, the leasing deferral at Kasegaluk Lagoon Special Area expires in 2014, and the coastal area between Icy Cape and into Peard Bay would be available for a potential corridor for Chukchi Sea development; the K-6 Lease Stipulation to restrict facility development within three-quarters of a mile of the coast does not apply to that coastal area. However, portions of that coastline have begun to receive heavy use as walrus haulouts. Therefore there is potential for oil and gas infrastructure (such as a pipeline landing) to be juxtaposed with walrus haulouts.

Under Alternative D, Kasegaluk Lagoon Special Area would be retained, K-6 Stipulation would apply to all NPR-A Chukchi coastlines, and a potential development corridor could exist anywhere along the NPR-A Chukchi coastline. Because K-6 applies to Alternative D, cumulative effects to walrus would probably be less than Alternative A.

Alternatives B-1, B-2, and C are similar in having the least potential for cumulative effects to walrus because: they each retain the Kasegaluk Lagoon Special Area (enlarged by 267,000 acres in Alternative B-1); each has a new Peard Bay Special Area; the Chukchi Sea development corridor would not be located across those special areas; and the K-6 Stipulation applies to all NPR-A Chukchi coastlines. Alternative B-2, while also retaining the Kasegaluk Lagoon Special Area and establishing a new Peard Bay Special Area, would have somewhat more potential for cumulative effects to walrus given that a Chukchi Sea development corridor could be authorized in these two special areas.

Conclusion

Bowhead Whale and Ice Seals

A few whales and seals do or could experience sublethal or lethal effects from entanglement in fishing gear, collisions with ships, or encounters with subsistence harvesters. Many activities related to oil and gas development onshore on the North Slope and within the NPR-A would not impact bowhead whales, ringed, or bearded seals directly. Any associated increase in barge and other vessel traffic would contribute to cumulative impacts to these species through the increased potential for deflection, disturbance, the masking of sounds, and increased discharge. Increased exploration and development in the Beaufort and Chukchi seas, in the Canadian Beaufort Sea, and in the eastern Russian Arctic would also increase vessel and aircraft activity, with associated effects similar to those described for other marine mammals in 4.8.7.10.

While specific effects of climate change and ocean acidification on bowheads, ringed, and bearded seals are uncertain, ice seals, in particular, may experience loss of habitat and changes in prey distribution and availability. Changes in shipping seasons and timing are also possible with diminishing sea ice and longer ice-free seasons. The most likely effect that these species will be exposed to is additional vessel traffic in the future (Reeves et al. 2012). Bowhead whales could display a cumulative response to activities that produce underwater noise by increasing their distance from such sources by temporarily diverting their route of travel, or by temporarily changing their behavior. As noted earlier a threshold may exist beyond which the number of behavioral changes and displacements may begin to have an effect on individual fitness. If the cumulative increase in disturbance events results in impacts to the fitness of enough individuals, reduced reproduction could result with consequences to the population.

Unfortunately, there are currently no well-established quantitative analytical techniques to assess cumulative effects from multiple stressors. Therefore it is difficult to determine whether the contribution from NPR-A activities combined with other effects such as climate change, sea ice reduction, shipping, contaminant transport, and offshore oil and gas activities has had or will have cumulative effects to marine mammals. Increased activity in NPR-A could add incrementally to the accumulation of stressors to marine mammals.

A large or very large oil spill that reaches marine waters has the greatest potential to adversely impact bowhead whales, ringed, and bearded seals, and could result in other effects becoming significant. For example, if a very large oil spill removed a substantial portion of the population, subsistence hunting and take from collisions and entanglement that are currently managed at sustainable levels, could act to further depress the population. Bowhead whales that come into contact with freshly spilled oil could suffer temporary, non-lethal effects, and a few whales could suffer lethal effects. Seal species however, could experience significant lethal effects. Bowhead whales could also be displaced by oil spill clean-up activities.

Humpback and Fin Whales

It is not known if the extralimital sightings of humpback whales and fin whales in the Northeast Chukchi and Beaufort seas represent a range shift, however, it is known that North Pacific humpback whale abundance is increasing (Allen and Angliss 2010) and the population may be expanding into the high Arctic. The BLM chooses to consider them here against the event that they become regular visitors. Unlike the sections analyzing the direct and indirect impacts of the alternatives, humpbacks are given a separate section in the Cumulative Effects section because the past and present effects that may have affected humpback and fin whales are somewhat different than those affected bowhead whales. Because of their rarity, industrial development on the Arctic Coastal Plain and in the Beaufort and Chukchi seas are not expected to have had prior cumulative effects on humpback and fin whales.

Polar Bear

The main factor of concern for polar bears range-wide, and for the populations that utilize NPR-A, is climate change. Changes in the extent and timing of sea ice are expected to have a significant impact on polar bears through alteration of their distribution, nutritional status, reproductive success, and ultimately their abundance. Oil and gas activities, with respect to polar bears, would be regulated under the Marine Mammal Protection Act and the Endangered Species Act, and will be limited to causing negligible effects to polar bears. But fuel and oil spills could cause mortality of polar bears and their prey, possibly with local population impacts. While other threats are managed or are not currently thought to be significant threats to polar bear populations, each could become significant in combination with future effects of climate change and the resultant loss of sea ice.

Pacific Walrus

The main concern for the Pacific walrus population is climate change, which is leading to the dramatic loss of their sea ice habitat and potential for changes in prey distribution and abundance. Changes in walrus behavior and habitat use are occurring. For example, walrus have begun utilizing the Alaska Chukchi coastal areas differently in response to the lack of sea ice in late summer, there may be an emergence of new marine mammal diseases, and there are concerns about the ability of local prey bases to support higher numbers of walrus for long periods. While other threats are being managed, or are not currently thought to be significant threats to the walrus population, each could become significant in combination with future effects of climate change.

4.8.7.12 Cultural Resources

Cultural resources, including prehistoric and historic sites and materials as well as traditional cultural properties, have a very limited ability to withstand cumulative adverse impacts. Cultural resource sites are not a renewable resource and risk being impacted by ground disturbing construction activities, oil and gas exploration and development, scientific excavation and data collection, natural processes like erosion, and unauthorized collection. Cultural properties result from a wide range of prehistoric and historic human activities including camps, cabins, hunting and fishing sites, graves, and areas of traditional religious or cultural importance. These sites can lose their integrity and scientific value when they are impacted as a result of natural or human disturbance. Almost without exception, cultural resources are present within the surface/near-surface of the landscape; the location most susceptible to impact. Disturbance and alteration in this zone comprises the greatest threat to cultural resources, followed by unauthorized collection.

Archaeological data indicates that human occupation of the North Slope began roughly 14,000 years ago when the Bering land bridge was present. At that time there was no arctic coast, and the regional landscape in the northern half of the NPR-A, the prime area for hydrocarbon accumulations, was much different than today. Episodes of climate change since that time have altered the landscape significantly. Modern sea level was not established until 6,000 years ago and the landscape of today is less than 8,000 years old. As a result, today's landscape provides only a partial insight into regional land use by past human populations. It is assumed, and supported by survey data, that cultural materials could be encountered anywhere within the region. Unlike the northern portion of the Reserve, in the southern NPR-A the geomorphology is basically unchanged since the end of the last glacial period, enabling predicting, with reasonable accuracy, past land use patterns and the location of archaeological sites. However, there is little indication of hydrocarbon presence in the southern portion of the Reserve and only a very slight chance that oil and gas exploration would take place there.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Before oil and gas exploration and development, North Slope cultural resources were subject only to the effects of natural conditions such as ecosystem alteration and the establishment/growth of villages. More recently, non-oil and gas activities, including field camps and associated data-gathering programs, scientific studies, overland transportation/freight hauling, construction associated with village and military expansion/development, recreational use such as guided float trips and big game hunts, and the use of utility terrain vehicles and snowmachines, have had effects on cultural resources. Archaeological excavation, which is usually necessary for the recovery of scientific data from cultural sites, has contributed directly to the displacement of cultural resources, as has incidental unauthorized collection of cultural material which is usually associated with recreational activities. In the early days of freight hauling between villages, construction of Distant Early Warning-Line and other military sites, and village-related development, impacts to the surface/near-surface of the landscape occurred regularly. Those impacts were primarily the result of the lack of regulations governing such activities and the low level of awareness and concern as to the potential adverse effects. However given the scope and extent of an estimated 7,100 acres that may have been adversely affected, only a small amount of direct impact to cultural resources seems to have occurred.

While a small amount of cultural material has been discovered as the result of ground disturbing activities associated with human undertakings on the North Slope, most cultural sites are revealed as the result of natural erosion. While some sites are exposed as a result of water initiated erosion, most are exposed by aeolian (wind) erosion as well as cryoturbation (the action of seasonal freezing and thawing), and solifluction (the downslope the movement of soil as it thaws). Natural erosion, and its impact on cultural resources, is difficult to assess because in most cases it is regarded as positive as it facilitates discovery rather than as a negative impact although there are negative effects. Overall, most of the known cultural sites on the North Slope have been discovered because cultural material was exposed on surface as a result of some type of natural erosional activity. However, what is a serious future concern is what the effect of global warming will be on the North Slope permafrost regime and the subsequent impact on cultural resources.

Oil and Gas Exploration and Development Activities

Ground-disturbing activities associated with oil and gas exploration and development have impacted cultural resources. During early seismic work the methods and equipment used to transport camps across the landscape were less environmentally friendly than those used today. Early technology required long, intersecting seismic lines with data acquisition accomplished primarily by drilling boreholes, loading the holes with dynamite and detonating the dynamite to produce the force waves. Prior to the mid-1970s, awareness of and regulations regarding impacts to the landscape were not prevalent.

The excavation of gravel to construct roads, pads, and other facilities since the mid-1960s has resulted in impacts to cultural resources. On the North Slope, areas of gravel accumulation are, by their geologic nature, usually well drained or at least better drained than the surrounding ground. Well-drained locales make the best camping spots, and in a region dominated by wet tundra and standing water, they are at a premium. As a result well-drained locations often have cultural sites associated with them, as past gravel mining activities have demonstrated. As a consequence, the more gravel deposits that are excavated for development, the greater the possibility of impacts to cultural resources. To date, roughly 7,000 surface acres have been disturbed for gravel mines on the North Slope leading to the extraction of an estimated 495 million cubic yards of gravel.

During the past several decades, greater reliance on technologies that reduce the need for gravel to construct permanent roads and pads and reductions in the size of the facility footprint, as well as a slowing of oil development activities, have substantially reduced the amount of area disturbed annually to extract gravel resources. In addition, regulations that require surveys for and prohibit unauthorized collection of cultural materials have also slowed the cumulative impact to cultural resources.

Summary of Past and Present Effects and Their Accumulation

Effects to cultural resources from road and pad construction, gravel mining, and disturbance associated with development and production activities have occurred in the past and the potential for impact continues today. Cultural and paleontological research and excavation, non-oil and gas development, recreation, and oil and gas exploration and development have resulted in impact to cultural resources on the North Slope, either from stratigraphic disturbance, destruction, or unauthorized collection. If cultural resources removed in the past have been preserved in museums or other institutions, their losses probably should not be tallied as negative cumulative impact. In the areas of the North Slope that are open to oil and gas exploration and development, about 2,500 acres have been disturbed or covered with gravel as a result of non-oil and gas development activities. In association with oil and gas exploration and development, approximately 1,750 acres have been disturbed by blading roads and establishing exploration sites, and airstrips. As of 10 years ago, gravel mining had disturbed about 6,400 acres. It is estimated that another 9,200 acres have been covered with gravel. While some cultural resources in these areas have undoubtedly been damaged, destroyed, or buried under gravel most of these impacts have occurred outside the NPR-A. Recent technological developments, including use of snow trails, ice roads and pads, low surface pressure vehicles, horizontal drilling, and development that does not require a gravel road linkage to the Prudhoe Bay/Kuparuk infrastructure have reduced the amount of surface disturbance associated with exploration and development activities, with likely benefits to the preservation of cultural resources.

Generally speaking, over the last 30 years, federal and state regulations, as well as management stipulations pertaining to cultural resources, have slowed the cumulative impacts to cultural resources.

Future Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Cultural resources are distributed continuously but unevenly across the North Slope. Within the NPR-A, landforms with high probabilities of prehistoric and historic use are reasonably predictable in the foothill/mountain portion of the Reserve but less so in the north. In large part this is due to the fact that geomorphic variation in the countryside of the northern half of the NPR-A is minimal compared to that in the south. In the north there is a sameness to the landscape that makes it difficult to ascertain the site location preferences of prehistoric people. Additionally, because of the vegetation regime, prehistoric sites are less frequently exposed on surface in the north than they are in the foothill/mountain region and therefore their presence is less apparent as are their numbers. Thus, prehistoric cultural resources in the northern NPR-A, the region of high oil and gas potential, have a greater chance of being discovered as a result of disturbance to the near-surface zone of the ground. These circumstances make it difficult to assess the potential future cumulative impacts to prehistoric cultural resources. On the other hand, historic cultural resources, because they are so recent, tend to lie on the surface of the landscape and are much more visible and easily identified than prehistoric cultural sites.

It is anticipated that village-related development will continue across the North Slope apace with that of oil field development. In most cases, this can be viewed as infrastructure expansion, which generally equates to building gravel pads and access roads and trenching for water and sewer lines as well as gas lines for local use. Cultural resources are susceptible to impacts resulting from these activities. Recreational use is expected continue to increase primarily in the form of guided float trips and big game hunting mostly in the foothill/mountain region and along the streams of the Colville and Utukok drainages. Other than unauthorized collection, it is anticipated that there will be no measureable impacts to cultural resources associated with these activities. Future scientific studies and the seasonal camps that support them will continue and may increase due to wide-ranging concerns over the effects of climate change. The impact of all of these studies will be ameliorated by the scientific and educational information that is obtained. Wintertime overland transportation activities will probably also increase although in most cases it is anticipated that established routes will continue to be used. Coupled with winter conditions, this should greatly reduce potential impacts to surface/near-surface cultural resources.

Oil and Gas Exploration and Development Activities

The more oil and gas associated activities that occur and the larger the area affected, the greater the possibility that cultural resources in the NPR-A could be impacted. Because of their surface/near-surface stratigraphic contexts, cultural resources are not well protected by soil and are vulnerable to any surface/near-surface disturbing activity. Exploration activities could be viewed as more likely to affect cultural resources than development activities, because basic exploration activities, such as seismic work, ice road and pad construction, and overland travel generally affect a greater surface area than the construction associated with development. Although in most cases snow cover and frozen ground offer reasonable protection to cultural deposits, they may also render cultural resources difficult to recognize and avoid. Adding to this potential is the fact that most exploration-related operations occur in the low light conditions of winter.

Increased oil and gas development activities on the North Slope would result in an increased need for gravel for infrastructure construction. The excavation of up to 150 million cubic yards of gravel equates to about 2,200 acres of surface/near-surface impact on the North Slope by the end of this century. Many prehistoric and historic sites are located on well-drained ground, and on much of the North Slope, well-drained ground often equates with gravel deposits. Gravel deposits are not common in the northern portion of the NPR-A and as a consequence will probably be fully exploited. As more gravel deposits are excavated, the probability for impacts to cultural resources increases. As previously mentioned, (see section 4.3.2.2, "Oil and Gas Exploration and Development Activities", Volume 2) pipeline construction, especially buried pipelines, pose a heightened threat to cultural resources. The development of hydrocarbon accumulations in the NPR-A, however, is dependent on pipelines.

New innovations in technology that reduce the amount of surface disturbance associated with oil and gas activities and the current slowing of oil and gas development on the North Slope, will contribute to the future protection of cultural resources and slow the cumulative impacts. As in the past, assessments to identify and protect cultural resources prior to the initiation of surface disturbing activities will be a major factor in reducing future cumulative adverse effects to cultural resources.

Contribution of NPR-A IAP/EIS Alternatives to Cumulative Effects

The greatest potential for adding to cumulative effects to cultural resources would occur under Alternative D, as all lands within the NPR-A would be available for leasing, and the amount of development proposed under the alternative is greater than for the other alternatives. The potential for cumulative effects under Alternative C would be about 25 percent less than D while Alternative A, the no-action alternative, would be about 43 percent less than D and Alternatives B-1 and B-2, which emphasize the protection of non-oil and gas resources, would be about 52 percent less than D. Because cultural resources have the potential to occur almost anywhere on the North Slope and their location of occurrence is unpredictable, it is difficult to develop a scenario of future cumulative impact.

Umbrella coverage and protection for cultural resources on federal lands is provided by the National Historic Preservation Act. In this IAP/EIS, Required Operating Procedure/Best Management Practice E-13 states that lessees will conduct a cultural resources survey prior to engaging in any potential ground disturbing activity. If cultural resources are identified during surveys, BLM guidelines and policy require that all potential effects to the resource be mitigated to the satisfaction of the land manager. Additional protection is provided by Required Operating Procedure/Best Management Practice C-2, which affords protection to stream banks, minimizes soil compaction, and impacts to the surface and near-surface of the landscape. Also contributing to the protection of cultural resources is Required Operating Procedure/Best Management Practice I-1 which requires that all personnel involved in oil and gas related activities, be made aware of environmental concerns, including cultural resources, that relate to the region/work site. Additional protections that are set out in select biologically sensitive areas also provide protections for cultural resources in that the flood plains, terraces, and banks of specific rivers, which are known to contain cultural material are safeguarded by construction setbacks. Contributing to these protections are the inventorying and monitoring that has been conducted in the NPR-A by the BLM, cooperators, and permittees both prior to and since leasing began. Carrying forward these and similar protections into the future should provide markedly positive results in reducing cumulative adverse impacts to cultural resources within the NPR-A and overall to the North Slope.

Conclusion

From a cumulative perspective more cultural sites have been disturbed and cultural material removed from the North Slope in general and the NPR-A in particular as the result of scientific studies than has been destroyed or removed through unauthorized collection resulting from oil and gas exploration and development as well as other construction related activities. While the scientific value and significance of the material that was obtained through scientific work is known, the value and significance of material obtained through unauthorized collection or that was destroyed will never be known. This is the greatest potential cumulative impact to cultural resources.

Because of the varying circumstances of occurrence surrounding the location and vulnerability of cultural resources, the significance of future impacts to the resource is difficult to assess in terms of the cumulative case. However, if the protections that are currently in place carry forward, then the cumulative impact would be expected to be minor within the NPR-A.

It should be mentioned that the future effects of climate change are currently unknown regarding future potential cumulative impacts to cultural resources. Climate change will cause alterations to the environment, ecosystems, and habitats of the North Slope, and if substantial enough could affect cultural resources. The thawing of permanently frozen ground could result in the erosion of river banks and beach bluffs, which could result in impacts to known and undocumented cultural deposits. Climate change will probably cause the alteration of weather patterns and an increase in the frequency and intensity of spring and fall storms with the potential to adversely affect near-shore cultural sites.

In the case being considered here, Alternative B-1 would contribute the least toward cumulative impacts. Alternatives B-2, A, C, and D progressively have a greater potential for creating cumulative impacts as all of those alternatives allow more area to be open for leasing.

4.8.7.13 Subsistence

The Iñupiat of the North Slope of Alaska have created, over the span of their history, a set of tools, behaviors, and cultural values that enabled them not merely to survive, but to thrive and expand into much of the Arctic, from Greenland to Siberia. Only in the last 180 years has contact with Euro-Americans gone from seasonal trading to long-term occupation, and only in the last 60 to 90 years have semi-nomadic Iñupiat settled into sedentary villages and been subjected to managed hunts and the cultural pressure of Euro-American dominance of commerce, government, and media. The central conflict for the Iñupiat on the North Slope, since the beginning of prolonged contact with Euro-Americans, has been the use and control of lands, competition for renewable resources, and the efforts by Euro-Americans to impose changes in the culture, lifeways, and behavior of the Iñupiat through regulation. Since the mid-19th century, the Iñupiat have adapted to external pressures (e.g., commercial whaling, trapping, reindeer herding, military construction, oil and gas exploration and development) and regulatory actions (e.g., state and federal regulations and International Whaling Commission quotas). The following discussion addresses key events (past, present, and reasonably foreseeable future) and the impacts that these key events have had on subsistence activities over time and could have in the future. Despite changes, the value of maintaining relationships with the land and resources through hunting and gathering activities and associated kinship and sharing remains and continually reinforces the importance of subsistence to the Iñupiat of the North Slope.

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Prior to sustained contact between the Iñupiat of the North Slope and Euro-Americans, the Iñupiat were a highly mobile, geographically widespread, and technologically capable people who lived in dispersed, small communities based on family and social connections. They harvested local resources as needed and as available, with large numbers of people aggregating at certain points along the edges of the sea ice for trading fairs and for the harvest of bowhead whales. Once a sufficient number of whales were harvested, they held a giant festival and feast, dividing whale products among participants, and then dispersed throughout the landscape again. This pattern continued into the 19th century, with intermittent contact with Russian, American, British, and Norwegian traders, explorers, missionaries, and government representatives. This contact intensified when commercial whaling north of the Bering Strait began in the 1850s (Stephen R. Braund and Associates and Institute of Social and Economic Research 1993).

Commercial whaling north of Bering Strait lasted approximately 60 years and introduced a number of impacts to the people and resources of the North Slope. Among these impacts were intermarriage, disease, the introduction of new foodstuffs including flour, sugar, coffee, and tea, the increased availability of alcohol and tobacco, ongoing efforts at acculturation of the Iñupiat through missions and government schools, and efforts to centralize and make sedentary the highly mobile populations of Iñupiat. The failure of commercial whaling by 1910 coincided with a depletion in the number of whales available for harvest, making subsistence harvest difficult for the Iñupiat along the Arctic coast. During the same era there was a significant decrease in the Iñupiat population due to influenza epidemics, tuberculosis, and poor health care. Iñupiaq and whale populations gradually recovered during the 20th century and the Iñupiat returned to their highly dispersed way of life, with additional emphasis on fur trapping and reindeer herding as a source of money to buy Euro-American goods to which they had become accustomed. However, the Great Depression and the subsequent collapse of the fur industry created very difficult economic times for many Iñupiaq families.

In 1954, the Department of Defense contracted for the construction of the Distant Early Warning-Line and subsequently the co-located White Alice Communication System sites on the North Slope as part of a pan-Arctic curtain of radar coverage and communications systems that spread from Greenland to the Aleutians. Industrial outposts were constructed every 50 miles along the coast, often at or near villages or other important subsistence or residence sites. Construction of a large Distant Early Warning-Line site on Barter Island drew Iñupiaq people from across the North Slope to settle there for jobs, although the construction of the site's airstrip required relocation of the local inhabitants and the destruction of several houses, ice cellars, and graves. Construction and operation of these sites by military contractors resulted in contamination of the surrounding area with fuel, oil, PCBs, antifreeze, and other chemicals. Beginning in the 1970s, many subsistence harvesters became aware of the dangers posed by chemical contamination and local inhabitants began to avoid these areas.

Impacts to subsistence resources in the modern era have been the result of various direct and indirect forces. The general subsistence resources and patterns of the six North Slope villages within the geographic scope considered for this analysis are described in detail in section 3.4.3 (Volume 1). Although recreation, overland moves, and other temporary ground activities may have temporarily disturbed subsistence resources, the primary non-oil and gas activity that has impacted subsistence is aircraft use.

Iñupiat have intensified the use of specific resources (e.g., bowhead whales, caribou, and furbearers) and a decline in the use of other species and resources (e.g., brant, goose and eider eggs, and long-tailed ducks). Regulatory restrictions and changing tastes have limited Iñupiaq harvests of certain resources such as moose and muskoxen. Constant advances in motorized transportation have helped support the mixed economy and subsistence practices, partially mitigating the effects of concentrated populations and high levels of activity in particular areas by making travel faster and easier, although at greater cost in monetary resources. Avoidance of formerly utilized harvest areas due to industrial activity is also made possible by motorized transportation, which allows subsistence users to travel farther and faster than in the past.

Oil and Gas Exploration and Development Activities

Although Native Alaskans had been tending to settle around missions, schools, and trading posts since those institutions had been introduced, local ecological conditions (i.e., subsistence resources) still rigidly restricted the number of inhabitants that any community could sustain. In the 1920s, the establishment of the Naval Petroleum Reserve and subsequent exploration activity marked the beginning of resource extraction activity in lands occupied by the Iñupiat of the North Slope. With PET-4 exploration and Naval Arctic Research Laboratory, the military's presence in Barrow transformed North Slope demographics and subsistence patterns, as opportunities for year-round wage labor inspired many men to abandon their reindeer herds and trap lines to move to town. Barrow had a population of approximately 330 in 1930 and had grown to 1,274 by 1957. In describing her experiences during this period in scoping statements for Outer Continental Shelf Lease Sale 170 in 1997, Lucy Ahvakana shared an indigenous person's view of the changes brought by the introduction of oil and gas exploration and development to a remote and technologically isolated population.

> When I was married to my first husband, we had a trading post in Foggy Island and Beach Pine, my first husband and I. We always go back and forth, trade, foxes, furnishing the food for Eskimos. Trappers live here. All of us -- a lot of us didn't get a chance to go to school. No school up here. You -- BIA didn't have enough money to put a school up here. They were trying to. And then we heard this oil company is coming. I moved to Barrow and these expeditions -- these looking for oil, Navys came. We went to Barrow. My husband said I had to go to Barrow to get my kids to school. So when we went there, we saw a bunch of barges. I thought it was Japanese invaded the Barrow. We were scared. And my stepdad went to shore. They seemed peaceful. We asked them, "What's going on?" The Navy's up here. They are looking for oil 1945. There were eleven barges. I

> know that Captain John Bablin, Sr., was the navigator for them. I moved to Barrow at that time.

The Bureau of Indian Affairs was responsible for educating and promoting the welfare of the Iñupiaq people, as well as building a hospital and a school in Barrow. By 1950, the Bureau of Indian Affairs was requiring families with school age children to relocate to population centers (e.g., Barrow) so that the children could attend school. Construction of a hospital and churches at Barrow also encouraged North Slope residents to settle there, although some Iñupiat returned to traditional harvest areas seasonally.

World War II brought further changes to the Arctic, as many young men departed to fight the war, thereby removing a number of hunters from the area. The war further denuded the land by encouraging more migration to hub communities from remote camps, and almost every single male resident of coastal villages enlisted in the Alaska Territorial Guard and was issued gear and powerful rifles that they used to hunt much more efficiently. World War II also increased the need for oil for naval vessels and industry, and began a period of intensified exploration and drilling activity on the North Slope

Postwar oil exploration and the sustained contact with Euro-Americans resulted in additive impacts on subsistence resources, harvest patterns, and users. The establishment and enforcement of state and Federal game regulations affected harvest activities and patterns and encouraged the development of indigenous means of countering regulatory efforts dictated from outside the region (e.g., the 1961 duck harvest protests in Barrow and the International Whaling Commission's limiting of bowhead whale hunting). Rosita Worl, in one of the early research reports of contemporary subsistence uses by Iñupiaq people, wrote that the "fate of subsistence lies not so much at the level of the hunter pursuing his game, but rather at the level of external pressures impacting his environment and regulatory actions that restrict his subsistence pursuits" (North Slope Borough 1980). These events contributed to the organization of the communities to effectively address the issues brought up by development pressure, and to defend the rights of the Iñupiat to maintain their way of life while incorporating the aspects of Euro-American technology and culture that they found valuable. They gave rise to organizations to defend the Iñupiaq people's interests (e.g., Alaska Federation of Natives in 1967, North Slope Borough in 1972, and the Alaska Eskimo Whaling Commission in 1977) which have made protection of subsistence rights one of their primary objectives.

The most intense oil and gas development activity, and increased impacts to subsistence activities, occurred during the 1970s and early 1980s (e.g., development of the Prudhoe Bay and Kuparuk oil fields and their associated roads, drilling pads, gravel sources, collector pipelines, and production facilities, construction of TAPS and the Dalton Highway). Increased oil and gas exploration and development activity helped prompt the North Slope Borough to initiate the Traditional Land Use Inventory (North Slope Borough 1980), a repository for information on historic sites and present land use (e.g., hunting camps and cabins). Oil and gas development in the Prudhoe Bay and Kuparuk areas discouraged Nuiqsut residents from using the eastern portions of their traditional harvest areas (Pedersen et al. 2000, ADFG Division of Subsistence 2001, Stephen R. Braund and Associates 2003b).

Over more than three decades, they have participated in public hearings for various industrial activities (e.g., lease sales, project scoping). During these hearings, the Iñupiat have consistently stated that they are concerned about the cumulative effects of industrial activities in their traditional subsistence use areas. Many articulate that oil and gas development is impacting traditional use areas and the ability of Iñupiat to pass on knowledge of subsistence resources in these areas, and use of these resources, to their children. They believe there is a decline of fish populations caused by seismic activities. They also report on the diversion of caribou from traditional migration routes and calving areas caused by an increased number of low flying aircraft, the disruption of caribou movements by low pipelines, the decreased use of traditional harvest areas due to the avoidance of industrial areas by hunters, and the fear of the consequences of oil spills on subsistence resources. Many of these concerns, as summarized in the Alpine Satellite Development Plan EIS (USDOI BLM 2004c) and brought up during meetings with North Slope residents, are presented in Table 4-44.

Seismic Activities and Exploratory Drilling. Impacts to subsistence caused by seismic exploration programs on the North Slope have been observed for many years. Although seismic testing no longer uses dynamite on fish bearing lakes, Iñupiat blamed this activity for declines in fish numbers in the vast number of interconnected lakes and streams used by subsistence fishermen. Arnold Brower, Jr. stated, at the 1998 Northeast NPR-A IAP/EIS scoping meetings, a consensus opinion among Iñupiaq subsistence hunters that seismic testing, even in its current refined form, deflects subsistence animals from the areas it operates in:

> I think I've heard that concern now from two other persons that directly told me that the existing seismic is already impacting subsistence hunters as we speak, that the seismic area has no game. The impacts, like Harry said, has scared and run the game off in one direction from that area already and numerous trips made by at least half a dozen hunters have attested that, that they've gone from the east side of the Ikpikpuk and Chipp River to the west side, where they're not there in that seismic area anymore. So these people have purchased gasoline and planned their trips just to find out that the seismic is in that area already and went up to those areas of normal hunting and the game is not there.

Iñupiaq representatives on the NPR-A Subsistence Advisory Panel have expressed disapproval of industry practices and governmental policies that allow much of the data gathered through seismic surveys to remain proprietary (U.S. Department of the Interior Bureau of Land Management Subsistence Advisory Panel (USDOI BLM Subsistence Advisory Panel 2011). Exact acreages surveyed are not always known, and the same areas can be explored by seismic survey multiple times – presumably because one company does not know what another discovered. Subsistence hunters see this as unnecessarily disturbing to subsistence activities and potentially damaging to the tundra.

Oil and Gas Development and Production. Development on land immediately east of Nuiqsut raised concerns about continued subsistence access in the early 1980s. Bessie Ericklook noted her concerns about subsistence access to the east side of the

Colville River and the effects of oil development on subsistence species in statements at a 1979 hearing on a proposed Beaufort Sea lease sale:

> Trapping was abundant east of here. Now, we don't go over because of the oil field. Just recently, it is known that the foxes are very dirty, discolored and rabid in that area. Trapping is done elsewhere. We used to see grizzly bears around. Now, they are not around. Where's the caribou now? One summer when we used to walk miles looking for caribou, came across two dead caribou for unknown reasons. The animals have faced a change. We have faced a change since activity began. If there is to be further activity, the fish and the sea mammals will suffer and we will suffer too. We depend on the fish, wildlife and the birds, still, today. Oil development poses a threat to our lifestyle.

Spills. The specific experience of oil spills in the ocean were described by several elders due to the extent of the damage caused by an incident in the 1940s. Described below is Thomas Brower's statement for the 1975 Beaufort Sea hearings in Barrow:

> I'm touching on this because of the fact that in 1944 or 45 when the Navy first came into this area, one of their tankers hit the bottom of the ocean, north of the point here, and they pumped 25,000 gallons of crude oil into the ocean; and as that thing scummed the ocean and started drifting toward these islands that you are talking about; it just hung in wide strips, some 40 to 50 feet wide along the edges of those islands. And all the ducks that came near it and the fur-bearing animals or the mammals (like the seal) went through it were soon blinded and thousands of them perished and I just don't know what happen to the fish that passed through those areas, but I'm pretty sure many of them died too.

This experience became the model for concerns about threats to subsistence species and continued use of these resources by Iñupiat people as oil development rapidly spread west from Prudhoe Bay. The National Research Council's Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope found that the public perception of oil spills on land is that they have greater impacts than they actually do: most terrestrial spills to date have had only local effects, and there is no evidence that effects of spills have accumulated. However, the impacts of oil spills in marine environments and the public perception of the risks of such spills are much higher. Some NPR-A residents are profoundly concerned about impacts to marine resources and oppose any oil development in the marine environment.

Summary of Past and Present Effects and Their Accumulation

Modernization has transformed the technology associated with subsistence hunting and fishing. The mixed, subsistence-market economy allows Iñupiaq hunters to purchase and utilize modern equipment that in turn allows them to travel further and faster. This flexibility often enables them to avoid conflicts with industry or with other subsistence users, and to hunt and fish more quickly and efficiently. These improved tools used for subsistence are less important than the accumulation of past events such as missions, schools, military sites, and the other advances of industrialization that led to sedentarization of the Iñupiat: settlement into permanent communities of previously dispersed people has had a profound impact on subsistence patterns. One result of regulatory restrictions, changing tastes, and modern hunting equipment is that Iñupiat have changed their dependence on specific resources: people eat more caribou and harvest more furbearers, for example, but eat a smaller variety of birds.

In recent decades, subsistence users have become concerned about the encroachment of industrial development on traditionally used land, chemical contamination of fish and game, the impacts and repetition of seismic survey, and about the potentially catastrophic impacts of a large oil spill in the marine environment. At the same time, many people welcome the economic benefits of oil and gas activities in their region. Table 4-44 provides examples of comments and concerns attributed to oil and gas activities that have been voiced by North Slope Iñupiat and other long-term North Slope residents in recent decades.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
Physical characteristics		
Aquatic environment (water resources; surface water; estuarine waters and water quality; marine water quality; flooding regime; and ice conditions.)	**Comment:** As a result of past action the Itkillik River, which was once clear, is now a rusty color. **Effects:** Decreased water quality and a lack of fish in the Itkillik River, and less fish for subsistence use. **Area:** Itkillikpatt and the Itkillik River.	Bessie Ericklook, 1979 Beaufort Sea Lease Sale, public hearing in Nuiqsut.
	Comment: Fresh water river levels near Nuiqsut are decreasing and rivers are getting shallower and shallower each year. **Effects:** Lower fish population and less fish for subsistence use. **Area:** Nuiqsut and surrounding rivers.	Flora Ipalook, 1979 Beaufort Sea Lease Sale, public hearing in Nuiqsut.
	Comments: Loss of 2 to 3 feet of water in area lakes especially Shinmar Rock; level went down to 5 to 6 feet and therefore it cannot support any more fish. **Effects:** Less fish present due to decrease in water levels and increase in noise, and less fish for subsistence use. **Area:** Shinmar Rock.	Arnold Brower, Sr., 1976 Federal Energy Hearings, public hearing in Barrow.
	Comment: Lakes and rivers are shallower than in past. Streams and rivers that shoot off of Tsukpuk Lake use to be navigable by boat but they can't even go on them. **Effects**: Decreased access; reduced fish populations; less fish available for subsistence use; and less available area for hunting and fishing. **Area:** Tsukpuk (Teshekpuk Lake).	Daniel Leavitt, 1979 Beaufort Sea Lease Sale, public hearing in Barrow.
	Comment: All drilling operations consume a lot of water. The same thing will happen like it did to the Sagavanirktok River; it ran completely dry twice in 1 year. **Effects:** Less animals and fish in area. **Area:** Sagavanirktok River.	Raymond Neakok, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Comment: A combination of built up ice and snow drifts and water rising with the tide causes area flooding. **Effects:** Flooding to 12 miles upriver causes danger for those with a dog team or on snowmachine, and less accessible area. **Area:** Howuerenokto and Ocean Point.	Nuiqsut Whaling Captains Meeting, 1996 Northstar EIS Project.
Atmospheric environment (climate and meteorology; air quality; and existing ambient air quality)	**Comment:** High winds and larger than average swells. **Effects:** Increase in swells, which inhibited ability to travel to and from subsistence area. A decrease in subsistence due to decrease in safe travel. Area: Cross Island.	Archie Ahkiviana, 2001 Liberty Project, public hearing in Nuiqsut.
	Comments: She (former health aid and physician's assistant) has noticed an overwhelming increase in asthma patients. The village makeup has not changed, still mostly Iñupiat. The most overwhelming issue was that the oil development around the community had increased and gotten closer. The worst nights were nights with many natural gas flares, as they release particles and some infiltrate the ground. Ahtuangaruak reported that Nuiqsut residents were seeing changes in the caribou and fish leaving them with lesions and tumors. Helicopter activity has diverted caribou away during hunting/subsistence gathering. **Effects:** Burning of natural gas and petroleum products has increased risk for respiratory problems in local residents. Increase in noise due to air traffic spooks caribou herd thus decreasing amount present in area. Infiltration of particles has caused disease in animals. **Area:** Nuiqsut and immediate surrounding areas.	Rosemary Ahtuangaruak, Mayor of Nuiqsut, 2003 Alpine Slope Development Plan, public hearing in Nuiqsut.
	Comments: He is worried about pollution, specifically, noise pollution displacing animals, and environmental pollution in terms of vehicle exhaust and dust that could go into rivers and on the ground affecting the habitat and health of animals that are used for subsistence. **Effects**: Pollution **Area:** Areas of Proposed Development	Charles Hugo, May 2012, Anaktuvuk Pass Subsistence Hearing on NPR-A DEIS/IAP
Biological Resources		
Fish	**Comments:** Use of explosives has killed or damaged many fish under the ice (traditional methods of harvesting involved using a hammer to strike the ice creating a noise killing the fish). **Effects:** Smaller fish population due to increase in noise and less fish for subsistence use. **Area:** Finmore Rock, Sitkulik and the Tripp River area.	Arnold Brower, Sr., 1976 Federal Energy Hearings, public hearing in Barrow.
	Comment: Use of explosives and compressors, especially in the winter months, has killed off or caused the relocation of those fish in local rivers and lakes. A method used by his father to gather fish involving pounding on ice to kill fish then drilling an opening downstream to gather the fish is no longer a feasible means of collection for him. Lakes where	Josh Tukle, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	the fish are inland freeze over in the winter and they die due to lack of water. A compressor which sends off a very loud noise and vibrations can also kill a lot of fish. **Effects:** Decreasing fish population. They are no longer able to use methods passed down through generations for harvesting fish. **Area:** Rivers in the area between Barrow/Nuiqsut to Anaktuvuk Pass.	
	Comments: We had some good fishing grounds up there and this fall we hardly even caught any. After the PET-4 seismograph party went through the depth of the lake is a little over 8 feet and a few blasts would clean the whole thing up. Traditional methods of hitting the ice then harvesting them out of the river downstream proved ineffective. **Effects:** Fish were not present following blasting and seismic activity and indirect effects as less fish available for subsistence use. **Area:** Area not specified.	Charlie Edwardson, 1976 Federal Energy Hearings, public hearing in Barrow.
	Comment: In an area where drilling had occurred, a net was placed in the lagoon near the ocean where my dad used to catch Arctic char. Even though we had the net there overnight we did not catch any fish. **Effects:** Fish population has declined in areas where drilling has occurred and less fish available for subsistence use. **Area:** Prudhoe Bay.	Jenny Ahkivgak (Okkingak), 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.
	Comments: Markers of the sounders that had been placed near the river. From that time on, the fishes in that river changed and are not there anymore right now. Sounders are killing them or driving them to the bottom of the stream. **Effects:** Fish were not present following sounding and less fish for subsistence use. **Area:** Area not specified.	Noah Itta, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.
	Comments: Since the use of dynamite in the river, there have been fewer and sometimes no fish found. They also disturbed the garden where they live off of. **Effects:** Fish not present after blasting events (up to 3 years after) and less fish available for subsistence use. **Area:** Area not specified.	Noah Itta, 2001 Liberty Development and Production Plan, public meeting in Nuiqsut.
	Comment: Fished in the Fish Creek area for Arctic cisco with mother (2 generations), since start of Alpine few years ago, hardly any fish to be caught in same area. **Effects:** Less fish in Fish Creek area. An indirect effect is less fish available for subsistence use. **Area:** Fish Creek, Nuiqsut, and surrounding areas.	Jimmy Nukapigak, 2003 Alpine Satellite Development Plan, public hearing in Barrow.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Comments: CD-6 is close to Fish Creek area where they fish in the summer. When they can't get fish in the Nigliq Channel they slide over to the other channel. It has lots of fish and they taste better than Colville fish. **Effect:** Putting in CD-6 could possibly disturb area and effect population of fish in the area historically and currently used for fishing. **Area:** Around proposed for CD-6 and Nigliq Channel area.	Frank Long, Jr. 2003 Alpine Satellite Development Plan, public hearing in Nuiqsut.
Birds	**Comments:** In Inigok where a lot of drilling took place, bones were seen from birds that have been killed from the stuff they leave behind in the hole. Wildlife and waterfowl dying from contaminants being left after having conducted drilling activity. **Effect:** Contamination of waterfowl and wildlife resulting in death and steady decrease in migratory bird population. **Area:** Upulatook near Nuiqsut; Inigok.	Thomas Brower, Jr. and James Aiken, Sr., 1997 1998 Northeast IAP/EIS, scoping meeting in Atqasuk.
	Comment: There's a lot of activity out there, and occasionally we have mortality events in either fish, caribou, or waterfowl, and these essentially go unaddressed. **Effect:** Increased mortality likely associated with increased development and human activity. **Area:** Area not specified.	Todd O'Hara, 2003 Amended IAP/EIS, scoping meeting in Barrow.
Mammals (terrestrial and marine mammals)	**Comments:** Seismic activity is displacing the animals. While hunting wolverines, which were being tracked, they had just been scared away from where activity (seismic) was occurring. There are no furbearers except for the foxes; did not see wolverines. **Effects:** Normal movement of animals is affected by activity making hunting and tracking more difficult and decreasing the number of available wolves and foxes for subsistence use. **Area:** Southside of Teshekpuk up in Pikes dunes and up the Ikpikpuk River.	Harry Brower, Jr., 1997 1998 Northeast IAP/EIS, scoping meeting in Barrow.
Caribou/Moose	**Comments:** Recreational use on the Prudhoe Bay Haul Road has denied Anaktuvuk Pass its access to the Porcupine Caribou Herd. It does not go there anymore. That used to be their main meat supply. **Effect:** Disruption of Porcupine Caribou Herd migration **Area:** Anaktuvuk Pass	George Edwardson, May 2012 Barrow Subsistence Hearing on NPR-A DEIS/IAP
	Comments: Since the pipeline, the Porcupine Herd no longer comes to Anaktuvuk Pass in springtime Now you don't see them anymore. **Effects:** Disruption of Porcupine Caribou Herd migration **Area:** Anaktuvuk Pass	Charles Hugo, May 2012, Anaktuvuk Pass Subsistence Hearing
	Comments: Aircraft use near Nuiqsut has displaced caribou from the community's cultural and traditional use areas, resulting in the inability to pass on traditional skills to younger generations. Stipulations that require less flights during prime harvest months are not enforced, and are no protection for this impact.	Rosemary Ahtuangaruak, May 2012, Barrow, Subsistence Hearing on Draft NPR-A IAP/EIS.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Effect: Aircraft disruption of caribou hunts **Area:** Nuiqsut	
	Comments: In August and September 2011, there were numerous flight by large aircraft into Umiat, resulting in moose staying south of the Umiat area. Hunters from Nuiqsut had to travel farther away to harvest moose and caribou. The community also had to request an extension to the moose harvest regulatory season. Caribou hunters were also impacted by these flights. **Effect:** Aircraft disruption of caribou and moose hunts **Area:** Nuiqsut, Umiat	Thomas Napageak, November 2011, Fairbanks, Subsistence Advisory Panel meeting
	Comments: Numerous flights by aircraft flying at low-levels ca. 25-30 miles south of Barrow resulted in a smaller than normal harvest of caribou. **Effect:** Aircraft disruption of caribou hunts **Area:** Barrow	Qinugan Roddy, November 2011, Fairbanks, Subsistence Advisory Panel
	Comments: Seismic testing involving dynamite is affecting caribou who consume the blasting powder; causes rabid behavior and effects on the animals. Caribou are affected by amount of waste materials. **Effects:** Poisonous powder used in blasting is being eaten by caribou thus decreasing well population and waste materials attaching to caribou (wires). Indirect effect is less healthy caribou for subsistence use. **Area:** Area not specified.	Raymond Neakok, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.
	Comment: The pipeline from Oliktok to Kuparuk has caused the displacement of caribou from Cross Island to Teshekpuk. Few caribou are crossing under pipelines and as a result there is displacement of caribou in the villages. **Effects:** Less caribou present following installation of pipeline. Less caribou available for subsistence use. **Area:** Oliktok to Kuparuk, from Cross Island to Teshekpuk.	Frederick Tuckle, Sr., 2001 Liberty Development and Production Plan, public hearing in Barrow.
	Comment: The 5 feet pipeline height had changed the caribou migration pattern due to past oil and gas developments. **Effects:** Disruption of caribou migration. Disruption of subsistence harvest and more effort required to harvest caribou. **Area:** Area not specified.	Isaac Nukapigak, 2003 Amended IAP/EIS, scoping meeting in Nuiqsut.
Social Systems		
Economy	**Comments:** Whether you support oil and gas, the community needs to support Alternative C as the primary choice here. The North Slope Borough survives on a tax base, and the more land leased the more infrastructure that can be created, the more the North Slope Borough will benefit to continue the services you have today. And that's what we need. **Effect:** Economic benefits of oil and gas development **Area:** Area not specified	John Hospon Jr,, May 2012, Wainwright Subsistence Hearing on Draft NPR-A IAP/EIS

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Comments: He believes there are benefits to oil and gas development, such as natural gas for heat, and water and sewage systems. The North Slope Borough benefits, local governments benefit, and future generations will benefit. Their forefathers made decisions so that all can benefit, and they need to make sure that industry follows the rules and regulations and stipulations on exploration and development. They have to be a part of the decision-making process in order to help make the right decisions for their community. **Effect:** Economic benefits of oil and gas development **Area:** Area not specified	Thomas Napageak, SAP Meeting, March 2, 2012, Barrow
	Comments: He feels that oil and gas development can be balanced with subsistence. He likes Alternative C, but feels that there's something blatantly, glaringly absent from it, namely, designating the entire Kuk River drainage as a special use area. **Effect**: Special subsistence use area protection **Area:** Kuk River drainage	Bob Shears, May 2012 Wainwright. Subsistence Hearing on Draft NPR-A IAP/EIS.
	Comments: Being a 3rd generation since pre-contact of Western civilization, they are faced with the fact they must either subsist off the land or take a 9:00-5:00 job. Cannot totally exist on subsistence anymore. **Effects:** Lifestyle drastically different than the way of their forefathers. Can no longer subsist off of the land and must work for the oil companies. Most are not qualified and jobs are short lived. **Area:** Barrow.	Sheldon Bogenrifle, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.
	Comments: Qualifications have changed for those natives who desire to work for oil related companies. In the beginning, the only qualification was that you pass the UA, now to get a regular labor job or driving job you need a clean UA, a driver's license or a CDL, unrestricted, and NSTC card. **Effects:** Fewer are qualified or eligible for employment through the oil industry. Less available money for those living in the villages without qualifications (who are no longer able to completely subsist). **Area:** Village of Nuiqsut.	Bernice Kaigelak, 2003 Alpine Satellite Development Plan, public hearing in Nuiqsut.
	Comments: We face the highest unemployment rates today, even though we can see the Alpine oil field just 7 miles away from Nuiqsut. **Effect:** Limited economic benefits to local communities as a result of development nearby. **Area:** Area not specified.	Isaac Nukapigak, 2003 Amended IAP/EIS, scoping meeting in Nuiqsut.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Comments: It is currently very difficult to find housing in Barrow due to use by oil and gas companies. Multiple generations of families are having to live together due to this housing shortage. **Effect:** Overcrowding and housing shortage due to competition from industry **Area:** Barrow	Bob Harcharek, Mayor of Barrow. May 2012 Subsistence Hearing on Draft NPR-A IAP/EIS.
Public Process	**Comments**: There have been numerous public process meetings by the Federal Government and Industry for the past 35 years, all focusing on asking local resident the same questions regarding what can be done to minimize impacts to their way of life. They answer the questions every time, but there is never any resolution. Instead, another meeting is held where the questions are asked over again. **Effect:** Disillusionment with public process **Area:** Anaktuvuk Pass, entirety of NPR-A	Bass Gordon, May 2012, Anaktuvuk Pass Draft NPR-A EIS/IAP Subsistence Hearing
Subsistence Harvest and Uses	**Comments:** The continuous development from the east going west has heavily impacted some of their hunting grounds. She is also very concerned of future development because more infrastructures are being placed, which will divert our hunting grounds, make our hunting game that much further out to try to harvest. **Effect:** Reduction in subsistence harvest opportunities. Longer distance and increased effort required to obtain harvests. **Area:** Area not specified.	Annie Lampe, 2003 Amended IAP/EIS, scoping meeting in Nuiqsut.
	Comments: We're going further and further inland to hunt caribou, but when they do come around our area, it's a blessing and a curse because a lot of these animals are sick. And then when you don't catch what you need, you have to rely on the income that comes in. **Effects:** Increased effort required to obtain harvests. Decrease in the quality of local harvests. **Area:** Area not specified.	Big Bob, 2003 Amended IAP/EIS, scoping meeting in Barrow.
	Comments: The residents of our communities rely upon these resources for the sustenance of our families. The cost of obtaining western staples is often out of reach of many families. The health of our community is dependent upon our resources. Any activity that causes changes to our harvesting of the subsistence resources will impact upon our families. The sharing of our resources with our extended families ripples down with losses for them also. **Effects:** Reduced community health. Effects beyond the hunters themselves. **Area:** Area not specified.	Rosemary Ahtuangaruak, 2003 Amended IAP/EIS, scoping meeting in Nuiqsut.
Land uses, ownership, and management	**Comments:** After catching a muskox he was taken to court for being inside the industry boundary. Must now fight in court for harvesting in certain areas. **Effects:** Freely hunted subsistence areas are now trespassing on oil company land in order to reach the same	Arnold Brower, Jr., 1998 1998 Northeast IAP/EIS, public meeting in Atqasuk.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	areas restrictions on land use. Less muskox due to land use/ownership restrictions. **Area:** Area not specified.	
	Comment: Open areas are now impassable due to dynamite left behind and wires scattered over the area. **Effects:** Change in use of land and less land to subsist from. Smaller amounts of available animals for subsistence harvest. **Area:** Area not specified.	Ruth Nukapigak, 1979 Beaufort Sea Lease Sale BF, public hearing in Nuiqsut.
	Comment: Her grandparents had a sod house and a cellar in Prudhoe Bay; now, they are unable to even access the site. They have no right to it even though their ancestors were there before the oil fields were there. **Effects:** Loss of access and previously owned land to oil industry. **Area:** Prudhoe Bay.	Sarah Kunaknana.
Transportation (road systems; aviation systems; marine transportation systems; pipeline systems; ice roads and platforms; winter Rolligon travel; and Alaska Railroad Corporation)	**Comment:** In order to cross the pipeline sometimes it is necessary to travel up to 10 miles off course. **Effects:** Longer travel time; indirect effect-increase in disturbed area due to having to travel off previously disturbed paths. **Area:** Nuiqsut area.	Thomas Napageak, Leonard Lampe, and Arnold Brower, 1997 1998 Northeast IAP/EIS scoping meeting in Nuiqsut.
	Comments: A proposed pipeline to bring oil and gas from offshore to the TAPS across NPR_A will include a large amount of associated infrastructure and will be an impediment for caribou traveling both east-to-west and north-to-south. This infrastructure will have a negative effect on the both the Teshekpuk Lake and Western Arctic caribou herds. There's a very real possibility that the pipeline, roads, and other infrastructure will have a negative effect on the population and on movement pattern. Changes in movement patterns can have serious effects on subsistence hunters. If this pipeline is built, placement of the route will need to be very carefully considered. And everything we have learned about mitigating impacts of roads and pipelines on caribou will need to be used to minimize impacts to the population. **Effect:** Pipelines on caribou migration **Area:** NPR-A	Geoff Carroll, May 2012, Barrow Subsistence Hearing on Draft NPR-A IAP/EIS.
Hazardous materials/ Environmental Justice	**Comments:** As witnessed and experienced when working for the oil companies, toxic muds and caustic sodas are being dumped into the rivers and oceans. Most of the abandoned oil rigs I have worked on, the toxic muds are put in good little cubes, about 5,000 square yards of toxic muds go uncovered. The wastes are accumulating.	Raymond Neakok, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.

Table 4-44. Examples of North Slope concerns/information attributed to oil and gas activities provided at public meetings 1976-2012

Resource category	Observations of conditions and locations	Testifier
	Effects: Accumulation of toxic materials and waste. Indirect effects as animals are exposed to these hazardous materials. **Area:** Area not specified.	
	Comments: When he was a boy, in his hometown during the springtime oil companies would clean out their silt and place the oils outside. Birds would stick to the oil and become unable to fly, eventually dying. **Effects:** Birds dying from inability to escape from oil exposed to the environment. Less birds for hunting and subsistence. **Area:** Area not specified.	Laurie Kingik, 1982 National Petroleum Reserve – Alaska, subsistence hearing in Barrow.
	Comments: And these construction outfits, they bring in the old equipment, old run down—some of them older than I am, and when they break, the oil gushes out. It sprays all over. **Effects:** Release of oil to the environment. Area: Area not specified.	Big Bob, 2003 Amended IAP/EIS, scoping meeting in Barrow.
Noise	**Comment:** Not far from the Nuiqsut site they are conducting wildlife surveys by air and by foot creating an enormous amount of noise that upsets, disrupts, and displaces perhaps some of their only opportunity to go get their game, especially caribou in the area are scared and may run off because of these impediments that arrive are not natural. Hunters must go further to gather game. **Effects:** Fewer caribou present following activity and surveys; thus, fewer caribou available for subsistence use. **Area:** Colville River Delta to the east side by Ulumniak.	Ruth Nukapigak, 1998 1998 Northeast IAP/EIS, public hearing in Nuiqsut.
Visual/aesthetic	**Comment:** Flames out on the project oil platforms are very close to the whaling base of Nuiqsut called Cook Island so concerns on the migration and impacts to whales exist. Flames spook both the whales and crews who are harvesting whales for subsistence. **Effects:** Fewer whales in the area due to flashing gas flares. Increases danger for subsistence hunters. **Area:** Cross Island	Leonard Lampe, 1996 Northstar EIS Project, Nuiqsut public scoping meeting.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Non-oil and gas activities on the North Slope, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, cleanup of contaminated sites, and overland moves by transport vehicles, would continue to disturb terrestrial subsistence resources and cause users to avoid hunting in such areas while these activities are underway. The continued use of off-highway vehicles such as four-wheel vehicles damages habitat but can also impact subsistence access to popular hunting areas: if trails become so damaged they are rendered impassible, hunters may be prevented from traveling to an area or they may cause further damage by making new trails. Former Distant Early Warning-Line Stations, the adjacent active and inactive Air Force Radar Sites, other military sites, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future and subsistence hunters will continue to avoid them. Villages are likely to increase in size, and the amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 and then level off for the remainder of the 21st century (see section 4.8.2.1). Population is also predicted to increase and this may result in a greater use of subsistence resources.

Oil and Gas Exploration and Development Activities

Umiat Road and Pipeline. In 2010, the State of Alaska applied for permits to construct an all-season industrial gravel road to connect Umiat in southeast NPR-A with the Dalton Highway. The Corps of Engineers is currently the lead agency on an EIS for the proposal and is considering several alternative routes. There are likely to be important effects on subsistence by non-oil and gas use of the road, which would cut across north-south migration paths and potentially affect animals in the Teshekpuk Caribou Herd and Central Arctic Herd during some autumn and spring migration. The road would provide increased access to caribou by non-local hunters and, if hunting were not appropriately managed, this could result in a cumulative increase in caribou mortality. Also, caribou may adapt to the presence of a road in a way that does not substantially affect the herds, but may have a substantial effect on subsistence hunters that rely on specific paths of movement by migrating caribou.

Differing views have emerged on the North Slope regarding the effects of roads on subsistence. For example, some North Slope residents believe that roads could mitigate impacts on subsistence harvests from industry, could improve access to areas of the traditional subsistence range at times of the year when access would be difficult, would shift subsistence harvests to areas that are currently less utilized, and could change the mindset that has caused local subsistence users to avoid industry infrastructure. On the other hand, roads could have a detrimental effect on traditional patterns of subsistence harvests and resource availability. For example, a new road would increase access among Iñupiat and others to areas previously less utilized and would change the character of that area and could deflect subsistence resources and interfere with nesting waterfowl. Additionally, a road to Umiat that increased access would result in increased hunting competition between users. Although oil field employees are prohibited from hunting while in the area, potential users could be local or non-local. Therefore, the road to Umiat could result in synergistic impacts to subsistence because there may be multiple levels of disturbance that would be more than expected from each disturbance alone.

The Umiat road and pipeline would also increase the likelihood of additional impacts to fish to the east of the NPR-A and within the NPR-A because permanent infrastructure (e.g., roads, pads, pipelines, and causeways) and gravel mining are likely to continue contributing to changes in natural drainage patterns and water quality, alternations to physical habitat, barriers to fish movement, and increased water pollution. The road could also lead to synergistic pressures on fish in the Colville River and its tributaries due to greater use of the area for sport and subsistence fishing.

The Naqsraġmiut Tribal Council of Anaktuvuk Pass, the Anaktuvuk Pass City Council, and the North Slope Borough Fish and Game Management Committee (which has representatives from all eight North Slope Borough communities) passed resolutions in the spring of 2011 opposing the proposed road to Umiat. The resolutions state that the threats posed by the road include increased competition for subsistence resources and public access to important subsistence rivers, most notably the Colville. The Naqsraġmiut Tribal Council's representative on the NPR-A Subsistence Advisory Panel, Andrew Hopson, reported that the main concern is that sport hunters will be able to access hunting areas along the road before the caribou herds pass over it and that these hunters could shoot at the first caribou in the herd, which is widely understood to deflect the entire herd from its migration path. As described in section 3.4.3.4 (Volume 1), Anaktuvuk Pass is particularly dependent upon caribou. Lillian Gordon of the Naqsraġmiut Tribal Council explained the council's opposition:

> This road will come at a high cost for anyone who relies on caribou and fish for subsistence. It will change everything here because more access to our hunting lands will cause serious problems to our village. This road will not help us. We have no idea why this road should be built so quickly when no one knows what will happen to our caribou. (DeMarban 2011).

The Kuukpikmiut of Nuiqsut are equally concerned about the potential impacts of the proposed road. Traditional subsistence lands to the east, north, and southeast of Nuiqsut are already avoided by subsistence users because of oil and gas activities. The community is therefore particularly sensitive to the possibility of additional competition for resources coming from the south and southeast and potentially extending by boat into the core of their subsistence use are, the Colville River Delta.

The chairman and several members of the BLM's NPR-A Subsistence Advisory Panel are committed to using the full extent of the Panel's advisory authority to oppose the proposed road because they believe that it could effectively preclude a viable subsistence lifestyle in Anaktuvuk Pass and because it could encourage further development along an east-west line that will bifurcate the Arctic Slope, creating impacts for subsistence in other NPR-A communities.

Proposed Road to Access the Ambler Mining District. The State of Alaska is in the beginning phase of planning for access to the Ambler Mining District on the south edge of the Brooks Range in the Kobuk River watershed. Multiple options for access routes that are being studied at this time include all-season gravel roads and railroads. The road options would either connect to the Dalton Highway to the west or to a port somewhere on the western coast of Alaska. A railroad would begin from current rail in the vicinity of Fairbanks and Nenana. Most of these options would cut across the fall and spring migration path of the Western Arctic Herd, and some would also affect Western Arctic Herd wintering habitat. An estimate of acres of caribou habitat lost to a proposed road cannot be made at this time because the preferred option has not been chosen, but any loss due to a proposed road would accumulate with habitat losses due to developments within the Western Arctic Herd range in the NPR-A.

As described in section 3.4.3.2 (Volume 1): Subsistence Use of the NPR-A: Subsistence Use of the Western Arctic Caribou Herd, at least 43 rural communities (including the 6 NPR-A villages) rely on Western Arctic Caribou Herd as their primary terrestrial meat source. As a result, any activity that threatens the viability of the hard has profound consequences for the communities that live within or near its overall range. Concerns over the proposed Ambler access route are similar to those over the proposed road to Umiat, including increased competition for resources, possible deflection of caribou herds, and avoidance by hunters. Therefore, the route could result in synergistic impacts to subsistence because there may be multiple levels of disturbance that would be more than expected from each disturbance alone.

Chukchi Sea Development. Offshore development in the Chukchi Sea could come ashore either on BLM-managed lands (in Alternatives A, B-2, and D), on state lands south of Icy Cape, or on private lands, such as those owned by the village corporations of Point Lay and Wainwright. Wainwright, as an example, could be considered as an onshore hub due to its proximity to the areas of exploration, the harbor for smaller vessels provided by the Kuk River, and the fact that the village corporation owns the necessary land. In anticipation of possible use of the area for exploration and development, subsidiaries of the Olġoonik Corporation (the Wainwright village Alaska Native Claims Settlement Act corporation),have built gravel pads, an access road and a camp, and will build at least one more camp and possibly a helicopter pad to accommodate oil exploration personnel and activities. It is possible that subsidiaries of the Olġoonik Corporation could secure oil industry contracts to construct a complete new shorebase if a commercial discovery is made, and facilities would include administrative, maintenance, and housing infrastructure as well as transportation facilities that may include a marine dock along with roads connecting facilities. Future scenarios for Wainwright may include a road to the barge landing at the mouth of the river and a road to and use of the airfield and gravel pad at the nearby deactivated Distant Early Warning-Line/North Warning System radar station. Analogous infrastructure could also take place on lands close to Point Lay.

All alternatives accommodate a corridor for infrastructure associated with offshore development in the Chukchi Sea. The portion of that pipeline and road extending east from the NPR-A to the Trans-Alaska Pipeline System would likely have effects subsumed by (as opposed to being additive to) those of the Alpine-Kuparuk-Prudhoe Bay infrastructure or the Umiat road/pipeline.

Offshore oil and gas production in the Chukchi Sea could have additional impacts on fish that could accumulate. The permanent onshore support infrastructure associated with offshore activities would increase the extent of the anthropogenic footprint already projected to occur with NPR-A development, contributing to changes in natural drainage patterns and water quality, alterations to physical habitat, barriers to fish movements, increased water pollution, and oil spills. Causeways, docks, or other similar structures could further hinder or divert marine or anadromous fish migrations along the coast, with each coastline structure exacerbating the impact. If a pipeline were built east across the NPR-A, it could have effects on the Teshekpuk Caribou Herd and Western Arctic Herd. Caribou may be able to habituate to pipeline across the NPR-A. However, a pipeline would necessitate two oil pump stations or two gas compression stations located in the NPR-A with rotating crews and may result in an increased the increased chance of caribou herds being deflected from a migration route.

The support infrastructure for offshore activities could make it economically profitable to extract oil and gas reserves from areas within the NPR-A which would otherwise not be economically recoverable, causing a synergistic increase in disturbance sources within the NPR-A. In this scenario, the northern and southern areas of NPR-A could be to some degree divided by a strip of industrial development, including a network of pipelines and access roads. There is the potential for this scenario to have a major impact on subsistence resources and access to those resources. Furthermore, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a self-reinforcing system.

Beaufort Sea Development. Offshore development in the Beaufort Sea may require onshore processing facilities and would require onshore pipelines. Such facilities in the NPR-A would impact Teshekpuk Caribou Herd year round and may accumulate with other disturbances for that herd particularly during calving and insect-relief seasons. Impacts of these types during those seasons could at some point have population level effects on the Teshekpuk Caribou Herd, although it is not clear that has occurred for the Central Arctic Herd under similar circumstances. This support infrastructure would also have impacts on fish that would be additive to those created by onshore oil and gas activities as described above.

Alternative B-1 of this plan would preclude development along the entire length of the NPR-A coast from Barrow to the Nuiqsut owned lands just west of the Colville River. This would greatly reduce the economic possibility of development in that portion of the Beaufort and the outcome would be fewer disturbances for fish, caribou, and other terrestrial mammals. Under Alternative B-1, Beaufort Sea development north of NPR-A could still occur but exclusively use offshore facilities and an offshore pipeline.

The preferred alternative (Alternative B-2) would not prohibit onshore infrastructure for transporting oil recovered from the Beaufort Sea. If oil is developed in this region of the Beaufort and this plan allows it to come ashore, the distribution system from there to the Trans-Alaska Pipeline System may make it more economical to develop smaller oil and gas fields in the northeastern NPR-A in areas where leasing is available. This could produce a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's individual alternative scenarios analyzed in sections 4.3.13 through 4.7.13 (Volumes 2 and 3). Moreover, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a positive feedback loop. There is the potential for this scenario to have a significant impact on subsistence resources and access to those resources, particularly for Barrow and Atqasuk hunters if a pipeline to transport Beaufort Sea oil came onshore immediately west of the area surrounding Teshekpuk Lake where no infrastructure is allowed in the preferred alternative (B-2).

The harvest of marine mammals is a primary subsistence activity that is critically important to the Iñupiat, and offshore oil and gas production in the Chukchi and Beaufort seas has the potential to negatively impact populations of and subsistence access to marine mammals. Iñupiaq on the North Slope harvest far fewer walrus in modern times than during previous eras, thus disturbance to the walrus population from offshore oil development would not appreciably impact nutritional security. Nevertheless, the health of the walrus population is very important to the Iñupiat for many reasons, including the fact that walrus could be a significant food source in times of need. Walrus already appear to be suffering from climate change because they normally haul out, rest, and feed from the ice edge. In recent years, walrus have begun hauling out in summer on Alaskan and Russian coastal areas instead, which are more distant from their core feeding grounds on the sea floor of the Chukchi. The Chukchi is particularly shallow and produces an abundance of crustacea and mollusks that are choice food for walrus, which furrow through the mud floor eating and creating habitat for more food. If that sea floor were disturbed or contaminated by an oil spill, the walrus population could suffer. Also, spilled oil tends to collect between and under breaks in the sea ice, where many marine mammals spend time. Seals and polar bears are also very dependent on this habitat and are particularly sensitive to oil spills because oiled fur cannot provide the insulation they require to survive.

Most importantly, offshore oil activity in the Chukchi and Beaufort seas could cause whales to change their travel routes, which would make subsistence whaling more dangerous and less successful. A significant reduction in bowhead whaling would have serious negative impacts on the sociocultural systems in Iñupiaq communities, which are socially organized around whaling crews and whaling celebrations. The International Whaling Commission sets the quota for the number of bowhead whales that Alaska Eskimos may harvest. This quota is based on both the biological status of the bowhead whale stock, as well as the documented Alaska Eskimo cultural and subsistence need for bowhead whales. In response to concerns that noise, vessel traffic, and the potential for a catastrophic oil spill poses a threat to the feeding grounds of the western Pacific gray whales, the International Whaling Commission passed a resolution that the onset of oil and gas development programs is of particular concern with regard to the survival of this population. Because the North Slope is the fall migration path and feeding grounds of the bowhead whale, it is possible that the International Whaling Commission would seriously consider the effects of industrialization on the bowhead whale population. Although the International Whaling Commission is unable to directly control industrial activities, they are able to control the Alaska Eskimo subsistence harvest quota and could reduce this quota as a means of protecting the species when it is confronted with the effects of increased industrialization. If the International Whaling Commission considers the threat of industrialization large enough, it could reduce the Alaska bowhead whale quota to protect the stock. This quota reduction would have a serious subsistence and cultural effect on the Iñupiaq communities of the North Slope as well as to Iñupiat in other communities who receive whale meat from the harvest. Furthermore, a decrease in the harvest of marine mammals could correspond to an increase in the harvest of terrestrial mammals and fish to supplement the loss.

Commercial Gas Pipelines. Construction of gas pipelines would have short-term effects on wintering caribou if caribou are present during construction. This could affect both the Teshekpuk Caribou Herd and the Central Arctic Herd. Once buried, the pipeline would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor. Such a pipeline is not expected to affect fish in a direct manner that would contribute to cumulative effects on fish for the region.

A much greater impact from a gas pipeline would be effects from all the gas development that a pipeline would make possible (already analyzed under all alternatives) within the NPR-A and to the east and west. Commercial gas production on the North Slope would likely result in more infrastructure in the foothills area and in the subsistence use areas of Point Lay, Atqasuk, and Wainwright, thus increasing the area that subsistence users are likely to avoid and the habitat for subsistence species that may be impacted. Permanent facilities will likely compel subsistence hunters to travel further to harvest game at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Conventional Oil and Gas Development Between the Colville and Canning Rivers. Because Alpine is located within the Colville River Delta, satellites to the Alpine oil field complex are considered as part of the Colville-Canning area. The BLM assumes that the total growth of industrial footprint (gravel pads, etc.) in this area through this century could be 3,750 acres. A permit is expected for a bridge over the Niglik Channel of the Colville River to connect the new satellites to Alpine. Disturbance of caribou and other subsistence resources caused by additional development in this area would have additive impacts only if it occurred in areas and time periods separate from existing disturbances. Otherwise, these impacts could accumulate with those of existing disturbance. The area between the Colville and the Canning rivers represents much of the range of the Central Arctic Herd and in some winters is also an important habitat for some Teshekpuk Caribou Herd caribou. Disturbances in this area during caribou calving season would not accumulate with any similar impacts in the NPR-A because neither of those two herds calve in both areas. Permanent infrastructure in this area will likely contribute to future effects on fish that could accumulate.

Oil and gas activities in this area have already deterred subsistence hunters from using traditional hunting, fishing, and camping sites, even if they have allotments within the oil field. The continued expansion of activity and infrastructure in this area will increase the area considered off-limits by resource users, could deflect or divert important subsistence resources from their normal routes, and require users to travel further to harvest subsistence foods at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Unconventional Oil and Gas Development East of NPR-A. Cumulative impacts from these activities would be the same as for conventional oil and gas in this area. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on the time and place of the impacts.

Spills. Effects on subsistence resources from spills on land thus far in the NPR-A have not accumulated because the spills have been small and the clean-up and rehabilitation efforts have generally been successful. With increased development, there is an increased probability of spills entering aquatic habitats that could affect fish and marine mammals. Moreover, new oil and gas development in the Chukchi and Beaufort seas would create a greater probability of spills that would enter coastal waters and impact anadromous and marine fish. Spills in either environment would likely have sublethal effects on caribou and other terrestrial subsistence game, but effects on fish from even small individual spills in coastal waters could accumulate over time. Spills in marine environments that impact fish and marine mammals have the potential to create major negative impacts to subsistence.

Abandonment. Removal of pipelines and gravel pads, roads, and airstrips would create temporary disturbance to subsistence resources and activities similar to those associated with construction. If problematic stream structures were removed, positive cumulative effects to fish could result if fish reach habitats that were previously inaccessible. Abandoned gravel mines would provide additional overwintering and spawning habitat for fish. If gravel roads and pads are left in place, they could provide benefits as insect-relief sites for caribou and could be used by subsistence hunters for easier access to hunting grounds.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

The extent of expected cumulative effects on subsistence resources and subsistence access and other activities would vary depending on the alternative selected under this IAP/EIS. Total, long-term, direct and indirect impacts to habitat from exploration and development combined would occur on 0.14 percent (Alternative B-1) to 0.29 percent (Alternative D) of the NPR-A. However, functional loss of subsistence use areas due to actual avoidance zones and displacement of resources would involve a much greater area. Because the area that is most likely to be developed for oil under the alternatives (economic zones 110 and 120, section 4.2.1.2, "Discovery and Development", Volume 2) includes the most important calving and insect-relief habitat for Teshekpuk Caribou Herd caribou, impacts to subsistence users who depend on this resource could be much greater than that predicted based solely on the number of acres disturbed. If avoidance areas increase and if impacts to caribou and other subsistence resources accumulate, this would affect the long-term sustainability of subsistence activities. In addition, impacts to the Western Arctic Herd from management decisions within the NPR-A could affect the over 40 communities that harvest Western Arctic Herd animals. These impacts would be added to any impacts resulting from a possible road to Ambler or expansion at the Red Dog Mine.

Impacts to subsistence resources and use areas on the North Slope from future oil and gas exploration are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past and present oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of subsistence use areas impacted by oil and gas development, and would be additive for the most part. However, if a pipeline for offshore oil is constructed across the NPR-A and this makes economic the development of additional fields, which would not otherwise have been economically developable, there would be synergistic effects on the amount of subsistence use areas affected.

The cumulative effects to subsistence resources and access to subsistence use areas would be least under Alternative B-1 because much of the area where impacts could accumulate to caribou and fish would be unavailable for leasing and because new permanent infrastructure in the coastal zone would be prohibited with a limited exception in the Kuk River and Wainwright Lagoon. The effects to subsistence would be greatest under Alternative D, since the entire NPR-A would be open to leasing with fewer mitigations than under other alternatives. The cumulative effects to subsistence resources and access under the preferred alternative (B-2) would vary to a high degree depending on the particular subsistence use area and whether and where infrastructure associated with offshore development is developed. Alternative B-2's prohibition of leasing and new infrastructure in the area around and north of Teshekpuk Lake and in most of the Utukok River Uplands Special Area would protect critical habitat of the Teshekpuk Lake Caribou Herd and the Western Arctic Caribou herd.

Conclusion

Oil and gas exploration and development activities on the North Slope have greatly impacted subsistence activities. Exploration and development could affect subsistence user areas of each NPR-A community. Iñupiaq hunters are reluctant to use firearms near oil production facilities and pipelines, so subsistence users would be unlikely to harvest subsistence resources in these areas. Aircraft have interfered with hunts by scaring game away from hunters, and an increase in air traffic by fixed-wing aircraft and helicopters would make this worse and over a much greater area if development goes forward. Oil and gas development is impacting traditional use areas and the ability of the Iñupiaq to pass on knowledge of subsistence resources in these area, and use of these resources, to their children.

Development along the north side of Teshekpuk Lake under those alternatives that allow it could deflect or divert caribou hunted in and near the area by Nuiqsut, Barrow, and Atqasuk residents in the summer and winter (Stephen R. Braund Associates 2003b). Numbers of animals available for harvest could be reduced through the slow reduction in populations by habitat loss, predation, climate change, and disease. Diverting animals from their usual and accustomed locations, or building facilities in proximity to those locations, could compel resource harvesters to travel further to avoid development areas. Harvest of subsistence resources in areas further from the communities would require increased effort, risk, and cost on the part of subsistence users. Increasing the areas open for leasing and exploration could lead to development in previously unavailable areas, concentrating subsistence harvest efforts in undeveloped areas and increasing the potential for conflict over harvest areas within a community.

Oil and gas exploration and development in the Chukchi and Beaufort seas could alter the migration of bowhead whales and other sea mammals, such as walrus and bearded seal, all of which are important subsistence resources for North Slope residents. These impacts would be devastating to North Slope communities should the changes in migration reach the point of causing failed harvests, especially failed bowhead whale hunts. In addition, any reduction in the Alaska bowhead whale quota made by the International Whaling Commission would have a serious subsistence and cultural effect on the Iñupiat communities of the North Slope, as well as to Iñupiat in other communities who receive whale meat from the harvest.

Onshore support facilities for oil development in the Chukchi and/or Beaufort seas that could include pipelines and access roads are reasonably foreseeable developments that could make it economical to develop more oil and gas fields within the NPR-A. These developments would cause synergistic increases in disturbances to subsistence use areas and to several subsistence resources.

The proposed road and associated pipeline to Umiat from the Dalton Highway could have substantial negative impacts on subsistence activities, in particular for Anaktuvuk Pass and Nuiqsut. The road could have traffic amounts similar to the Dalton and would almost certainly be open to the public. Non-local hunters would almost certainly use the road to hunt caribou, and the road would result in easy public access to the Colville River and thus by boat to the Colville Delta and Beaufort Sea as well as to any navigable tributary of the Colville. The road, pipeline, traffic, and hunters would be in the path of north-south migration routes and could potentially affect caribou from the Teshekpuk Caribou Herd and Central Arctic Herd during some autumn and spring migrations. The state is undergoing the permitting process to build the road with the hope that it will help promote oil and gas development in the area and within NPR-A. The project could likely make it economical to develop more oil and gas fields within the NPR-A. These developments would cause synergistic cumulative disturbances to subsistence use areas and possibly to subsistence resources.

Isaac Nukapigak, subsistence hunter and President of Nuiqsut's Kuukpik Corporation, contends that Native subsistence hunters harvest virtually no game within a 5-mile radius of oil and gas facilities and dramatically reduced amounts of game harvested within a 16-mile radius. He estimates that the area that would be avoided by subsistence hunters if the road to Umiat and pipelines from the Chukchi and Beaufort seas were built could be as large as 12,270 square miles (based on a 5-mile avoidance zone on either side of each linear structure) (Nukapigak 2012).

Climate change and the associated effects of anticipated warming of the climate regime in the Arctic could significantly affect subsistence harvests and uses if warming trends continue as predicted (National Research Council 2003, Arctic Climate Impact Assessment 2004). The reduction, regulation, and/or loss of subsistence resources would have severe effects on the subsistence way of life for residents of NPR-A communities. If permafrost loss increases as predicted, there could be synergistic cumulative effects on infrastructure, travel, landforms, sea ice, river navigability, habitat, availability of fresh water, and availability of terrestrial mammals, marine mammals, waterfowl and fish, all of which could necessitate relocating communities or their population, shifting the population to places with better subsistence hunting, and causing a loss or dispersal of community (National Research Council 2003, Arctic Climate Impact Assessment 2004).

4.8.7.14 Sociocultural Systems

The Iñupiat have developed sociocultural systems, including settlement patterns, kinship, leadership institutions, and cultural values concerning relationships with the land, as tools for successfully adapting to their arctic environment. The following discussion addresses key events (past, present, and reasonably foreseeable future) and the impacts that these key events have had or may have on sociocultural systems over time. This discussion focuses on sociocultural cumulative effects primarily involving changes in cultural values and social organization.

Past and Present Effects and Their Accumulation

Activities not Associated with Oil and Gas Exploration and Development

Impacts to the sociocultural systems of the Iñupiat of the North Slope have occurred since the first direct interactions with non-Natives in the first quarter of the 19th century. Since that time, the Iñupiat have adapted to new technologies, new external pressures (e.g., commercial whaling, trapping, reindeer herding, military construction, oil and gas exploration and development), and regulatory actions (e.g., state and Federal regulations and International Whaling Commission quotas). (See section 3.4.4 “Sociocultural Systems” [Volume 1] for a general discussion of Iñupiaq cultural values and kinship and section 4.8.7.13 “Subsistence” for an inclusive summary of key events in recent North Slope history). Adaptations to these external pressures resulted in intensified use of specific resources (e.g., bowhead whales, caribou, and furbearers). Commercial whaling north of the Bering Strait, which began in 1848 and ended in 1914, introduced a number of impacts to the people and resources of the North Slope including intermarriage, increased disease, new foodstuffs (e.g., flour, sugar, coffee, and tea), the increased availability of alcohol and tobacco, ongoing efforts at acculturation of the Iñupiat through missions and government schools, and efforts to centralize and make sedentary the highly mobile Iñupiaq populations. Missionaries arrived in the latter quarter of the 19th century to proselytize among the Iñupiat, operate federally-funded schools for the education and indoctrination of Iñupiaq youth, provide some level of medical care, administer reindeer herding and other social experiments, and care for orphans whose parents had died in epidemics and accidents. The missionaries considered these efforts as necessary to mitigate the impacts of commercial whaling and prolonged contact with Euro-Americans. Over time, the Iñupiat experienced a growing reliance on an external market system to purchase newly introduced technological innovations to support subsistence activities (e.g., firearms, traps, boat motors, and snowmachines).

The whalers depleted the populations of walrus and bowhead whales, creating extreme hardships or starvation for Alaska Natives that subsisted on those species. The end of commercial whaling also removed the local economy it had provided. Fur trading became the main economic pursuit capable of earning the money needed to purchase American goods, such as sugar, tea, tobacco, flour, coffee, and lard, demanded by the Iñupiat. The Iñupiat, whose population was further devastated by the 1918 influenza epidemic, dispersed along the coasts and rivers, pursuing furs, reindeer herding, and a subsistence way of life until the Great Depression drove fur prices so low that fur trapping was no longer a viable pursuit. Subsistence whaling continued as a practice and as the center of social and political organization on the North Slope, and as the populations of whales and Iñupiat gradually recovered in the 20th century, resettled communities began to field discreet bowhead whale crews (e.g., Nuiqsut and Kaktovik).

World War II brought important sociocultural changes to the most remote areas of the Alaskan Arctic, particularly once Dutch Harbor was bombed, two Aleutian islands were occupied, and the U.S. realized the both vulnerable and strategic position of Alaska. Many young Iñupiaq men departed to fight in the war and thus became particularly acculturated to mainstream American values, the English language, and world travel. In Alaska’s coastal villages, almost every single male resident volunteered for the Alaska Territorial Guard, the “Tundra Army” that defended the entire Alaskan coastline from Japanese attack. Alaska Territorial Guard commander Major ‘Muktuk’ Marston credited the organization with challenging institutionalized racism in the state and believed its influence led to passage of the Nondiscrimination Act of 1945 and the creation of the Alaska Federation of Natives. “[I]ndeed, it was the first time in history that these natives were regarded as bona fide citizens. As a result of the War, the natives were organized and aware of all local and national affairs. Many were for the first time exercising their right of franchise," (Marston 1969). Iñupiaq Alaska Territorial Guard members were very pleased with Marston's distribution of free rifles and ammunition, became legendary marksmen during their service in the war, and paved the way for regular territorial guard units and disproportionately high Iñupiaq participation in the military.

By the mid-20th century, Iñupiat settlement patterns had changed significantly. The population became centralized into a few communities, when they previously had been spread in small family-based units across the North Slope sea coast, river banks, and lake shores, and only gathered into centralized locations for temporary, communal hunts (e.g., whales, caribou, molting birds), trading, and festivals. Military projects further denuded the land by encouraging more migration to hub communities from remote camps: Barrow, where the military presence and related job opportunities began in 1944, had a population of approximately 330 in 1930 that grew to 1,274 by 1957. Although some Iñupiaq harvesters and their families often returned to traditional harvest areas seasonally, and in some cases those without school-aged children never left the traditional areas, by the late 1940s the Bureau of Indian Affairs required families to relocate to population centers (e.g., Barrow, Wainwright) so that children could attend school. In addition, construction of a hospital and churches at Barrow also encouraged North Slope residents to settle there.

World War II and the ensuing Cold War transformed Alaska into a permanent military defense perimeter for the nation. In 1954, U.S. Air Force contractors constructed 17 Distant Early Warning-Line radar stations, one every 50 miles, across Alaska's North Slope as part of a pan-Arctic system of early warning and communication to defend against Soviet over-the-pole attacks. Construction of the Distant Early Warning-Line had significant environmental and sociocultural impacts on the land and people of the North Slope. These largely civilian-run bases were often built on established Iñupiaq camps and use areas: land that was appropriated by the military without local inhabitants' knowledge or consultation. Although Barrow was already habituated and growing to regional dominance due to the military's decade-long presence there, other areas of the North Slope were unprepared for what inhabitants often perceived as a surprise incursion on their homelands. Construction brought an unprecedented number of jobs and scrap lumber and other materials that were used across the Arctic to construct framed houses—often the first framed buildings other than schools and churches. Compared to the semi-subterranean sod and driftwood frame homes that people had lived in, the framed shacks were cold and particularly prone to fire, which became more common with the concurrent arrival of 55-gallon drum oil-drip stoves, rudimentary electricity, and other advances. Years later, people learned that much of the building material contained asbestos, lead, and PCBs. The radar stations, with airstrips, jobs, stores, and infrastructure, helped solidify the modern establishment and survival of adjacent communities. The bases brought emergency health care, vehicles, processed food, Hollywood movies, and scores of male employees, some of whom married local women, were accepted into communities, and became influential entrepreneurs and leaders. Each site also had a large bar and a drinking culture, and the amount of alcohol that flowed through the bases into communities is regarded by many residents as the most significant social impact of the Distant Early Warning-Line (Fritz 2010).

Subsequent key events with particular sociocultural impacts on the North Slope include resistance to the proposed Project Chariot near Point Hope, which led to the founding of the first regional newspaper and an Iñupiaq alliance with scientists, religious leaders, and the environmental movement. A movement for land claims grew after statehood in 1958, and led to the conveyance of tracts of North Slope land to the State of Alaska and federal protection of what would become the Arctic National Wildlife Refuge. These land appropriations by the federal government contributed to anxiety over loss of control over traditional Iñupiaq land. The Vietnam War had sociocultural effects for the North Slope similar to the rest of the country, although many Iñupiaq veterans returned home emboldened to fight for Native land claims and their own people's self-determination. Following the passage of the Alaska Native Claims Settlement Act and the establishment of the North Slope Borough in the early 1970s, many traditional use areas and former villages were permanently resettled (e.g., Nuiqsut, Atqasuk, and Point Lay). In 1984, the Inuit Circumpolar Council was formed to strengthen ties between Inuit and Yupik from Russia, Alaska, Canada, and Greenland, and to promote human, cultural, political, and environmental rights at the international level. In recent years, Iñupiaq culture and daily life have been increasingly celebrated on social networking sites, which are enormously popular among North Slope residents.

Oil and Gas Exploration and Development Activities

Some initial exploration took place along the North Slope with the establishment of the Naval Petroleum Reserve in Alaska in 1923, but oil exploration and development did not fully commence until the U.S. Navy and its contractors arrived to intensively explore and drill in the reserve in 1944. The cumulative effects of subsequent oil and gas exploration and development on sociocultural patterns in recent decades are difficult to establish with quantitative precision given the lack of data (Kruse 2006). Nonetheless, there is evidence that North Slope sociocultural systems have been subject to ongoing, additive, and synergistic cumulative impacts. Section 4.8.3 provides a general history of key oil and gas-related events on the North Slope and, as stated in section 4.3.14, "Sociocultural Systems" (Volume 2), public comments indicate that a relationship exists between oil and gas development and social stress or well-being (Ahtuangaruak 1997).

Stress within North Slope sociocultural systems arises from residents' inability to access traditional use areas and threats to resources/lifeways and to Iñupiaq spiritual connection with the land. Since the passage of the National Environmental Policy Act in 1969, residents have dealt with complex policy and decision-making practices, resulting in a rapid assimilation to government processes and familiarization with the language of bureaucracy, both of which were necessary for local residents to fully participate in the decision-making process. Some residents are or perceive themselves as being ignored or discounted by agency representatives, which creates additional stress. The possibility of a large oil spill and its effects on bowhead whales and other marine mammals, fish, and wildlife also are of great concern to residents. Long-term anxiety over these issues accumulate because the issues are interrelated and are brought up anew with each lease sale, EIS, development proposal, and facility expansion (National Research Council 2003).

Economic factors are also critical to community well-being, however, and the North Slope has benefited from development. The revenues that have been collected by the

North Slope Borough from oil development have brought schools, clinics, water treatment plants, and building programs to North Slope communities that have significantly raised the standard of living and reduced anxiety. Furthermore, the State-administered NPR-A Impact Mitigation Grant Program and the success of the Arctic Slope Regional Corporation and its dividends to shareholders have brought even greater economic support and stability to North Slope communities.

Despite effects to sociocultural systems by oil and gas exploration and development, what has remained constant over time for Iñupiat is the centralization of leadership with whaling captains and their wives, a continued cultural and nutritional dependence on and desire for subsistence foods, a continued reliance on sharing and kinship, a continued connection to family camps and land use areas, and the desire to have control over their communities' present and future. Whaling captains often are in positions of power in city, borough, and other institutions, and the institutions conform to the Iñupiaq model of leadership and process. Subsistence foods are important for their nutritional value and their relatively low costs to the community, but most of all for the continued maintenance of the network of human and animal relationships, Iñupiaq identity, and the activity of hunting, processing, and sharing as an outlet for individual social stress and a means of reducing community stresses. The desire to have some control over the harvest areas they depend upon, and the stress resulting from development and activities that conflict with their values with no recourse, is a significant stressor to individuals and communities. Conflicts that are perceived to pit the Iñupiat against agencies and corporations contribute to feelings of futility, powerlessness, and despair, and if coupled with subsistence harvest shortfalls, pervasive unemployment, overcrowding, and other issues, could result in significant and serious sociocultural consequences (Impact Assessment, Inc. 1990).

As stated in section 4.3.14, "Sociocultural Systems" (Volume 2), North Slope Borough institutions, such as the school district that promotes the teaching of Iñupiat language and culture, the Arctic Eskimo Whaling Commission that negotiates with industry and the International Whaling Commission to protect Iñupiat subsistence whaling interests, the North Slope Borough Department of Wildlife Management, and other regional and village Native corporations and organizations, have worked to prevent the weakening of traditional Iñupiat cultural institutions and practices. Some conflicts can be mitigated, as in the case of "Oil-Whaler Agreements" which have lessened the impact of seismic and other industry operations on subsistence bowhead whale hunting at Cross Island (National Research Council 2003).

The encroachment of oil production facilities and infrastructure into areas formerly used for subsistence by the Iñupiat increases the difficulties faced by subsistence users in trying to provide culturally valued foods for their extended families. This encroachment to date has included the permanent oil infrastructure to the east, north, and west of Nuiqsut, as well as the winter exploratory drilling and seismic testing in Inigok and other staging areas. The cycle of oil exploration, development, and production activities, as it is conducted both offshore and onshore, has contributed to harvest shortfalls, a loss of cultural privacy, and challenge to traditional Iñupiaq values. Frustration stemming from the inability to provide for the extended family or exercise control over external factors further stresses people who are exposed to these problems. Rosemary Ahtuangaruak, a health aide and former mayor of Nuiqsut, stated the following in the 2001 hearings held for the Liberty project:

> One of the biggest issues that affects our community is the loss of control. In addition to the loss of subsistence opportunities, the major severe impacts result from the petroleum development in other areas of the Arctic. It is the lack of control over these events experienced by the village. Nuiqsut residents state they are the last to find out what's happening to them. They are never asked or generally considered about the pattern or course of the industry's development. They are merely informed after major decisions are in place. They would not spend the money making these studies if they were not planning to develop them. So it's a moot issue, after the fact. You're coming for the meeting, but you're already spending the money because you know this project is happening. This perception causes enormous social stress and tension. It is reflected in the increased community social ills, such as the alcoholism, the domestic violence, and the drug abuse. Thus, existing and potential activities further exacerbate and destabilize stress and tension resulting from almost 20 years of petroleum activities in the region. And since development would complete the pattern surrounding our traditional whaling site, it poses the most significant and long-term adverse social and cultural impacts of all the development of the North Slope, the potential for permanent reduction and/or loss of subsistence reserves, and thus, the viability of the Iñupiat way of life.

In response to these types of social disruptions, the North Slope Borough, Alaska Eskimo Whaling Commission, regional and tribal governments, and village corporations have instituted efforts to foster and protect Iñupiaq traditions. The BLM NPR-A Subsistence Advisory Panel is tasked with preventing conflicts between subsistence activities and oil and gas development, and making recommendations to the lessee and the BLM for resolutions to protect sociocultural values. Health and social services programs have tried to respond to alcohol and drug problems with treatment programs and shelters for abused spouses and families of abused spouses (USDOI BLM 2004c). Effective responses to other health issues, such as asthma, which is attributed by many local residents to exposure to increased pollution from oil field operations, in addition to a background of cold weather and other injuries and illnesses, suffer from funding shortages. Rosemary Ahtuangaruak stated the following during scoping for the Alpine Satellite Development Plan EIS (USDOI BLM 2004c):

> When I started as a health aide in 1985 I had one asthma patient. By the time I went to the University of Washington for my physician assistant certificate in 1989, I had 20 to 25. When I came back in '91, there were 35. When I quit in 2000, there were over 60. The village make-up has not changed; it is still mostly Iñupiat. What was contributing, the most overwhelming issue, was that oil development around the community had increased and gotten closer. The worst nights on call were nights with many natural gas flares occurring. We could see it in the flares or in the fields around us. They release particles and they travel to us. The chance of an inversion will affect us. An inversion is a bowl-like air trap with cold air trapped by warm air. Increased concentrations of particulate matter occur during these episodes.

Additional information regarding the potential cumulative impacts to human health can be found in section 4.8.7.21.

Summary of Past and Present Effects and Their Accumulation

Impacts to the sociocultural systems of the Iñupiat of the North Slope have occurred since the first direct interactions with non-Natives in the first quarter of the 19th century. Since that time, the Iñupiat have adapted to new technologies, new external pressures, and regulatory actions. By the mid-20th century, Iñupiaq settlement patterns had changed significantly. Military activities in Barrow and other North Slope communities brought jobs and many other aspects of modern industrial life. The population, previously spread in small family-based units across the North Slope, became centralized into a few communities.

The cumulative effects of oil and gas development on sociocultural patterns are difficult to establish with quantitative precision given the lack of baseline data. Nonetheless, there is evidence that North Slope sociocultural systems have been subject to ongoing, additive, and synergistic cumulative impacts, and that oil and gas development, the primary driver of change in recent decades, has contributed substantially to these impacts. Stress on North Slope sociocultural systems includes residents' inability to access traditional use areas, threats to resources/lifeways and to spiritual connection with the land, having to deal with policy and bureaucratic processes, and being ignored or discounted by agency representatives. Long-term stresses would result in greater impacts to sociocultural systems. The possibility of a large oil spill, and its effects on bowhead whales and other marine mammals, fish, and wildlife, is of great concern to residents. Anxiety accumulates because these issues are interrelated and are brought up with each new lease sale, EIS, development proposal, and facility expansion.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Because Iñupiaq sociocultural systems are inherently tied to land use and subsistence activities, the discussion of future effects to subsistence provided in section 4.8.7.13, under the heading "Future Effects and Their Accumulation," is also applicable for this discussion. Non-oil and gas activities on the North Slope, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, the persistence of contaminated sites, remediation operations, and overland moves by transport vehicles, could disturb subsistence resources and cause subsistence users to avoid such areas while activities are underway.

Former Distant Early Warning Line Stations as well as the adjacent active and inactive Air Force Radar Sites and other military sites, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 and then level off for the remainder of the 21st century. However, out-migration from North Slope villages is emerging as a major sociocultural concern for the North Slope Borough. Older North Slope Borough residents often move to Anchorage for steady health care. Younger generations have several reasons for moving to larger communities (i.e., from other North Slope Borough villages to Barrow or from the North Slope Borough to

Anchorage or Fairbanks or the Lower 48) that include the regular attractions of modernity and urban environments, including greater education and employment opportunities, larger and more varied social networks and cultural outlets, and easier access to a greater variety of consumer goods. Also, most North Slope Borough villages have severe housing shortages and the cost of rent, heating fuel, and other necessities is higher than in urban centers.

Oil and Gas Exploration and Development Activities

There are several significant oil and gas projects that are reasonably likely to occur in the NPR-A in the foreseeable future, and all of these potential developments can affect sociocultural systems through challenges to the subsistence way of life, through greater contact with non-Natives and their institutions, and through increased employment and income (whether from wages or Alaska Native Claims Settlement Act corporation dividends). Cumulative effects could include changes to social organization, and impacts to cultural values and general community welfare (e.g., health and education). Changes to social organization could potentially occur as a result of changes in population, employment, subsistence harvest patterns, social bonds, and cultural values. Recent oil and gas booms in rural areas of the contiguous U.S. have resulted in increased crime and traffic and higher housing and school costs. An increase in income in North Slope Borough communities could potentially result in an increase in social problems, such as drug and alcohol abuse and violence, as well as increasing conflicts from wealth disparities.

Umiat Road and Pipeline. In 2010, the State of Alaska applied for permits to construct an all-season industrial gravel road to connect Umiat in southeast NPR-A with the Dalton Highway. The Army Corps of Engineers is currently the lead agency on an EIS for the proposal and is considering several alternative routes. There are likely to be important effects on subsistence, and thus on sociocultural systems, by non-oil and gas uses of the road, which would cut across north-south migration paths and potentially affect animals in the Teshekpuk Caribou Herd and Central Arctic Herd during some autumn and spring migrations. The road would provide increased access to caribou by non-local hunters and, if hunting were not appropriately managed, this could result in cumulative increase in caribou mortality. Also, caribou may adapt to the presence of a road in a way that does not substantially affect the population of the herd, but may have a substantial effect on subsistence hunters that rely on specific paths of movement by migrating caribou.

The Anaktuvuk Pass City Council, the Naqsraġmiut Tribal Council of Anaktuvuk Pass, the Nuiqsut City Council, and the North Slope Borough Fish and Game Management Committee (which includes representatives from all eight North Slope Borough communities) passed resolutions in the spring of 2011 opposing the proposed road to Umiat. The resolutions state that the threats posed by the road include increased competition for subsistence resources and public access to important subsistence rivers, most notably the Colville. The Naqsraġmiut Tribal Council's representative on the NPR-A Subsistence Advisory Panel, Andrew Hopson, reported that the main concern is that sport hunters will be able to access hunting areas along the road before the caribou herds pass over it and that these hunters could shoot at the first caribou in the herd, which is widely believed to deflect the entire herd from its migration path. As described in section 3.4.3.4 (Volume 1), Anaktuvuk Pass is particularly dependent upon caribou. Lillian Gordon of the Naqsraġmiut Tribal Council explained the council's opposition:

> This road will come at a high cost for anyone who relies on caribou and fish for subsistence. It will change everything here because more access to our hunting lands will cause serious problems to our village. This road will not help us. We have no idea why this road should be built so quickly when no one knows what will happen to our caribou (DeMarban 2011).

Although the North Slope Borough would likely gain revenue from the increased development that the road to Umiat would make possible, there appears to be widespread agreement on the North Slope that the potential economic advantages of such development do not outweigh the possible disadvantages to the subsistence lifestyle and thus the core cultural values that Iñupiat prioritize. However, another and perhaps stronger common belief on the North Slope is that development of this type is inevitable regardless of what local inhabitants' opinions may be and all efforts should therefore focus on ensuring that such development has as little impact on subsistence as possible and on driving a hard bargain so that the North Slope Borough, ANCSA corporations, and communities derive as much of the economic benefit as possible.

Chukchi Sea Development. Offshore development in the Chukchi Sea could come ashore either on BLM-managed lands, on state lands south of Icy Cape, or on private lands, such as those owned by the village corporations of Point Lay and Wainwright. Wainwright, as an example, could be considered as an onshore hub due to its proximity to the areas of exploration, the harbor for smaller vessels provided by the Kuk River, and the fact that the village corporation owns the necessary land. In anticipation of possible use of the area for exploration and development, subsidiaries of the Olġoonik Corporation (the Wainwright village Alaska Native Claims Settlement Act corporation), have built gravel pads, an access road and a camp, and will build at least one more camp and possibly a helicopter pad to accommodate oil exploration personnel and activities. It is possible that subsidiaries of the Olġoonik Corporation could secure oil industry contracts to construct a complete new shorebase if a commercial discovery is made, and facilities would include administrative, maintenance, and housing infrastructure as well as transportation facilities that may include a marine dock along with roads connecting facilities. Future scenarios for Wainwright may include a road to the barge landing at the mouth of the river and a road to and use of the airfield and gravel pad at the nearby deactivated Distant Early Warning-Line/North Warning System radar station. Analogous infrastructure could also take place on lands close to Point Lay. If the Point Lay or Wainwright village corporation secures contracts and/or leases land for onshore infrastructure associated with offshore oil development in the Chukchi, that community will most likely experience direct economic and sociocultural impacts. The financial benefits could reduce anxiety about the community's future economic wellbeing, but anxiety could increase over population growth, negative impacts to subsistence resources and use areas, and the increased amount of industrial air and water traffic around the community.

All alternatives accommodate a corridor for infrastructure associated with offshore development in the Chukchi Sea. If a pipeline were built east across the NPR-A, it could have effects on the Teshekpuk Caribou Herd and Western Arctic Herd. The portion of that pipeline and road extending east from the NPR-A to the Trans-Alaska Pipeline

System would likely have effects subsumed by (as opposed to being additive to) those of the Alpine-Kuparuk-Prudhoe Bay infrastructure or the Umiat road/pipeline.

Offshore oil and gas production in the Chukchi Sea could have additional impacts on fish that could be cumulative. The permanent onshore support infrastructure associated with offshore activities would increase the extent of the anthropogenic footprint already projected to occur with NPR-A development, contributing to changes in natural drainage patterns and water quality, alterations to physical habitat, barriers to fish movements, increased water pollution, and oil spills. Causeways, docks, or other similar structures could further hinder or divert marine or anadromous fish migrations along the coast, with each coastline structure exacerbating the impact. Caribou may be able to habituate to pipeline across the NPR-A. However, a pipeline would necessitate two oil pump stations or two gas compression stations located in the NPR-A with rotating crews and may result in an increased chance of caribou herds being deflected from a migration route.

The support infrastructure for offshore activities could make it economically profitable to extract oil and gas reserves from areas within the NPR-A which would otherwise not be economically recoverable, causing a synergistic increase in disturbance sources within the NPR-A. In this scenario, the northern and southern areas of NPR-A could be to some degree divided by a strip of industrial development, including a network of pipelines and access roads. There is the potential for this scenario to have a major impact on subsistence resources and access to those resources. Furthermore, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a self-reinforcing system and associated repercussions on sociocultural systems, such as increasing anxiety over diminished use of traditional areas, real or perceived impacts to subsistence resources, and loss of control of land use decisions.

Beaufort Sea Development. Offshore development in the Beaufort Sea may require onshore processing facilities and would require onshore pipelines. Such facilities in the NPR-A would impact Teshekpuk Caribou Herd year round and may accumulate with other disturbances for that herd particularly during calving and insect-relief seasons. Impacts during those seasons could at some point have population level effects on the Teshekpuk Caribou Herd, although it is not clear that has occurred for the Central Arctic Herd under similar circumstances. This support infrastructure would also have impacts on fish that would be additive to those created by onshore oil and gas activities as described above.

If the BLM chooses Alternative B-1 of this plan, it would preclude development along the entire length of the NPR-A coast from Barrow to lands owned by Nuiqsut's Alaska Native Claims Settlement Act corporation, Kuukpik, just west of the Colville River. This would greatly reduce the economic possibility of development in that portion of the Beaufort and the outcome would be fewer disturbances for fish, caribou, and other terrestrial mammals. However, under Alternative B-1, Beaufort Sea development north of NPR-A might still occur but exclusively use offshore facilities and an offshore pipeline.

Alternatively, if oil is developed in this region of the Beaufort and this plan allows it to come ashore, the distribution system from there to the Trans-Alaska Pipeline System may make it more economical to develop smaller oil and gas fields in the northeastern NPR-A. This may produce a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's scenarios. Moreover, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a positive feedback loop. There is the potential for this scenario to have a major impact on subsistence resources and access to those resources and thus to sociocultural systems to the degree that said systems depend on the preclusion of industrialization in that area.

The harvest of marine mammals is of central cultural importance to the Iñupiat, and offshore oil and gas production in the Chukchi and Beaufort seas has the potential to negatively impact populations of and subsistence access to marine mammals. Iñupiaq on the North Slope harvest far fewer walrus in modern times than during previous eras, thus disturbance to the walrus population from offshore oil development would not appreciably impact nutritional security. Nevertheless, the health of the walrus population is very important to the Iñupiat for many reasons, including the fact that walrus could be a significant food source in times of need. Walrus already appear to be suffering from climate change because they normally haul out, rest, and feed from the ice edge. In recent years, walrus have begun hauling out in summer on Alaskan and Russian coastal areas instead, which are more distant from their core feeding grounds on the sea floor of the Chukchi. The Chukchi is particularly shallow and produces an abundance of crustacea and mollusks that are choice food for walrus, which furrow through the mud floor eating and creating habitat for more food. If that sea floor were disturbed or contaminated by an oil spill, the walrus population could suffer. Also, spilled oil tends to collect between and under breaks in the sea ice, where many marine mammals spend time. Seals and polar bears are also very dependent on this habitat and are particularly sensitive to oil spills because oiled fur cannot provide the insulation they require to survive.

Most importantly, offshore oil activity in the Chukchi and Beaufort seas could cause whales to change their travel routes, which would make subsistence whaling more dangerous and less successful. A significant reduction in bowhead whaling would have serious negative impacts on the sociocultural systems in Iñupiaq communities, which are socially organized around whaling crews and whaling celebrations. The International Whaling Commission sets the quota for the number of bowhead whales that Alaska Eskimos may harvest. This quota is based on both the biological status of the bowhead whale stock, as well as the documented Alaska Eskimo cultural and subsistence need for bowhead whales.

It is possible that the International Whaling Commission would perceive increased industrialization in the NPR-A and the rest of the North Slope, in particular the development of coastal staging areas, offshore oil development, and increased oil spill risks, as placing increased pressure on the endangered bowhead whale population. In response to concerns that noise, vessel traffic, and the potential for a catastrophic oil spill poses a threat to the feeding grounds of the western Pacific gray whales, the International Whaling Commission passed a resolution that the onset of oil and gas development programs is of particular concern with regard to the survival of this population. Because the North Slope is the fall migration path and feeding grounds of the bowhead whale, it is possible that the International Whaling Commission would seriously consider the effects of industrialization on the bowhead whale population. Although the International Whaling Commission is unable to directly control industrial activities, they are able to control the Alaska Eskimo subsistence harvest quota and could reduce this quota as a means of protecting the species when it is confronted with the effects of increased industrialization. This quota reduction would have a serious subsistence and cultural effect on the Iñupiaq communities of the North Slope as well as to Iñupiat in other communities who receive whale meat from the harvest. Furthermore, a decrease in the harvest of marine mammals could correspond to an increase in the harvest of terrestrial mammals and fish to supplement the loss.

Commercial Gas Pipelines. Construction of gas pipelines would have short-term effects on wintering caribou if caribou are present during construction. This could affect both the Teshekpuk Caribou Herd and the Central Arctic Herd. Once buried, the pipeline would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor. Such a pipeline is not expected to affect fish in a direct manner that would contribute to cumulative effects on fish for the region.

A much greater impact from a gas pipeline would be effects from additional gas development that a pipeline would make possible (already analyzed under all alternatives) within and to the east and west of NPR-A. Commercial gas production on the North Slope would likely result in more infrastructure in the foothills area and in the subsistence use areas of Point Lay, Atqasuk, and Wainwright, thus increasing the area that subsistence users are likely to avoid and the amount of habitat for subsistence species that may be impacted. Permanent facilities will likely compel subsistence hunters to travel further to harvest game at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Conventional Oil and Gas Development Between the Colville and Canning Rivers. Disturbance of caribou and other subsistence resources caused by additional development in this area would have additive impacts only if it occurred in areas and time periods separate from existing disturbances. Otherwise, these impacts could accumulate with those of existing disturbance. The area between the Colville and the Canning rivers represents much of the range of the Central Arctic Herd and in some winters is also an important habitat for some Teshekpuk Caribou Herd caribou. Disturbances in this area during caribou calving season would not accumulate with any similar impacts in the NPR-A because neither of those herds calve in both areas. Permanent infrastructure in this area will likely contribute to future effects on fish that could accumulate.

Oil and gas activities in this area have already deterred subsistence hunters from using traditional hunting, fishing, and camping sites, even if they have allotments within the oil field. The continued expansion of activity and infrastructure in this area will increase the area considered off-limits by resource users, could deflect or divert important subsistence resources from their normal routes, and require users to travel further to harvest subsistence foods at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Unconventional Oil and Gas Development East of NPR-A. Cumulative impacts from these activities would be the same as for conventional oil and gas in this area. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on the time and place of the impacts.

Spills. Effects on subsistence resources from spills on land thus far in the NPR-A have not accumulated because the spills have been small and the cleanup and rehabilitation efforts have generally been successful. However, given the magnitude of development scenarios for the NPR-A, lands to the east of NPR-A, and offshore, this situation could change. Spills associated with reasonably foreseeable future projects could potentially affect terrestrial mammals and there is an increased probability of spills entering aquatic habitats that could affect fish and marine mammals. Increased oil and gas development in the Chukchi and Beaufort seas would increase the likelihood of spills that would enter coastal waters and impact fish and marine mammals. Spills in either environment would likely have sublethal effects on caribou and other terrestrial subsistence game, but effects on fish and marine mammals from even small individual spills in coastal waters could accumulate over time. Spills in marine environments that impact fish and marine mammals have the potential to create major negative impacts to subsistence and thus stress to sociocultural systems.

Abandonment. In the event of oil field abandonment, the Iñupiat would likely be employed to assist in the removal and demobilization of the infrastructure, and would continue with their subsistence pursuits. The abandonment of oil fields and the related loss of revenue would no doubt have serious effects on the entire state of Alaska. Worldwide data suggest a consistent pattern of marked increases in stress, social problems, and emigration under circumstances of sudden or severe economic depression. Data from Iñupiaq populations has shown that economic depression correlates strongly with epidemic rates of suicide (Travis 1985), and the greater dependence on the global economy today than ever before indicates that economic collapse would have serious consequences. However, the collapse of commercial enterprise is seen as inevitable and is common over the history of the Iñupiat. Commercial whaling served the same markets as petrochemicals do today, and the Iñupiat survived by returning to the land. Fur trapping collapsed and the Iñupiat people adapted. Based on this historic demonstration of their resiliency, it would appear that the Iñupiat may be at less risk from the decline of industry than they are in the face of an expanding and unchecked industry. Less than 10 percent of Iñupiat history has proceeded in contact with Europeans and Americans, and in those 160 years they have maintained their unique cultural identity as a people throughout the Arctic.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

The extent of expected cumulative effects on sociocultural systems would vary depending on the alternative selected under this IAP/EIS, although no scenario is expected to result in overall impacts that would be more substantial than those caused by technology, other aspects of modernization, and climate change. Total, long-term, direct and indirect impacts to habitat from exploration and development combined would occur on 0.14 percent (Alternative B-1) to 0.29 percent (Alternative D) of the NPR-A. However, functional loss of culturally important areas due to actual avoidance zones and displacement of subsistence resources would involve a much greater area. Because the area that is most likely to be developed for oil under the alternatives (economic zones 110 and 120, section 4.2.1.2. "Discovery and Development" in Volume 2) includes the most important calving and insect-relief habitat for Teshekpuk Caribou Herd caribou, impacts to subsistence users who depend on this resource could be much greater than that predicted based solely on the number of acres disturbed. Also, gas development could overlap with the habitat of the Western Arctic Herd with similar effects. Impacts to the Western Arctic Herd from management decisions within the NPR-A could affect the over 40 communities that harvest Western Arctic Herd animals. These impacts would be added to any impacts resulting from a possible road to Ambler or expansion at the Red Dog Mine. If impacts to caribou and other subsistence resources accumulate, this would affect the long-term sustainability of subsistence activities and thus impact a primary driver of Iñupiaq sociocultural systems.

Impacts to subsistence resources and use areas on the North Slope from future oil and gas exploration are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past and present oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of subsistence use areas impacted by oil and gas development, and would be additive for the most part. However, if a pipeline for offshore oil is constructed across the NPR-A and this makes the development of additional fields economic (which would not otherwise have been economically viable), there would likely be synergistic effects on the amount of subsistence use areas affected.

The effects to sociocultural systems in terms of subsistence and culturally important areas would be least under Alternative B-1 because much of the area where impacts could accumulate to caribou and fish would be unavailable for leasing and because new permanent infrastructure in the coastal zone would be prohibited with a limited exception in the Kuk River and Wainwright Lagoon. However, Alternative B-1 could result in a lower revenue stream for the North Slope Borough, which would represent a negative sociocultural impact. The effects to subsistence could be greatest under Alternative D, since the entire NPR-A would be open to leasing with fewer mitigations than under other alternatives. Revenues to the North Slope Borough from oil would increase if many leases were sold under Alternative D.

Conclusion

Key events in modern history that have impacted Iñupiaq sociocultural systems include the period of commercial whaling and the introduction of disease, trading goods, and influential marriages. The settlement into permanent communities due to missions, schools, and trading posts had significant impacts as did the influenza epidemic of 1918-19. Fur trapping and reindeer herding provided a nominal cash economy in the 1920s and '30s, but the Great Depression and the collapse of the fur industry caused many North Slope residents to increase their dependence on subsistence. The military's arrival in Barrow in 1944 marked the beginning of Barrow's rise to dominance on the North Slope, and the PET IV exploration, Naval Arctic Research Laboratory, World War II, and the construction of the Distant Early Warning-Line brought industry and employment opportunities to many North Slope communities. Land claims were driven by the state and industry's interest in developing Prudhoe Bay and constructing the Trans-Alaska Pipeline System, and the formation of the North Slope Borough and Alaska Native Claims Settlement Act corporations led to a much higher standard of living with many modern amenities.

The substantially greater economic stability brought by oil development on the North Slope has helped mitigate much of the stress commonly associated with poverty and other issues in recently settled indigenous populations. However, several effects of climate change are particularly significant in the western Arctic. Climate change could cause changes to the environment and habitats of the North Slope that could affect subsistence resources and users, as discussed in section 4.8.7.13, “Subsistence.” The reduction of sea ice has exacerbated coastal erosion, the weather has become less predictable, the shore ice in spring is less stable for whaling, fall travel for caribou is hampered by a late and unreliable freeze up, ice cellars provide less reliable food storage, and the number of marine mammals that are experiencing habitat loss is apparent. All of these issues create significant concerns for the Iñupiat because they are perceived as factors that cannot be controlled and are threatening their way of life. Community anxiety could increase as a result, and traditional knowledge of the landscape, environment, and resources would be devalued if conditions change rapidly, reducing the influence of experienced elders in the communities. Despite their deep-seated faith in the ability of both Iñupiaq people and arctic animals to adapt to changing conditions, many Iñupiat are nevertheless disturbed by an ecosystem that appears to be out of balance.

Another long-term source of sociocultural stress is the conflict that is perceived to be inherent in dependence on continued development to ensure economic viability while also needing to protect subsistence resources and access and the promotion of that way of life. At the same time, some fear that both systems may eventually degrade and that dramatic outmigration could be the end result. Although the Iñupiat have weathered the boom and bust cycles of development in the past, many people feel that younger generations will not be willing or able to live without a functioning local economy. Although the success of Arctic Slope Regional Corporation could mitigate a downturn in local economy, the current standard of living for North Slope residents (already lower in real terms than the rest of the U.S.) will be impossible to maintain unless significant external sources of local revenue are found. The reasonably foreseeable oil and gas activities will likely forestall such an economic situation for at least several decades. If subsistence resources are diminished, it is realistic to expect that some general assistance could be found to mitigate the losses of nutrition, health, and income. However, such assistance would likely have little effect in mitigating the associated social and cultural impacts.

4.8.7.15 Environmental Justice

The intent of the environmental justice initiative is to promote fair treatment of people of all races so that no group of people bears a disproportionate share of the negative effects (particularly human health and environmental effects) from the country’s domestic and foreign programs. A 1994 Executive Order on environmental justice signified recognition that low-income and minority populations in the U.S. have been and continue to be subjected to unfair treatment regarding the environment and public health. There have been several events related to environmental justice in North Slope Iñupiaq history that have cumulatively contributed to the society’s perspectives on their own empowerment, to their relationship with the federal government, and that are relevant to current BLM management decisions.

In the NPR-A today, activities that impact subsistence resources and access to those resources could have a disproportionately high impact on minority and low-income communities. Alaska Iñupiaq Natives, a recognized minority, are the predominant residents of the North Slope Borough, the area that would likely be most affected by activities in the NPR-A under the five alternatives and activities associated with other projects on the North Slope. Environmental justice effects on the Iñupiat have occurred in the past from non-oil and gas, and from oil and gas impacts on their subsistence resources and harvest practices, as well as through impacts to human health (see section 4.8.7.21, "Public Health" for a detailed description of cumulative impacts to the health of local residents). Causes of cumulative effects would include climate change, onshore and offshore oil and gas activity, economic instability, oil spills, noise and traffic disturbance, local chemical pollution from industry, and other disturbances from construction activities associated with exploration and development on the North Slope.

It is expected that cumulative effects to subsistence resources, harvest practices, and sociocultural patterns from pollution, noise, disturbance, and terrestrial oil spills could impact each Iñupiaq community that is located within or near the NPR-A. Because this cumulative impact analysis includes a brief analysis of the potential effects of offshore oil and gas activities in the Beaufort and Chukchi seas, impacts to the more distant North Slope Borough communities of Point Hope and Kaktovik would also be an environmental justice issue. The BLM's actions within the NPR-A could impact the Western Arctic Caribou Herd, animals harvested by subsistence hunters in over 40 communities. Increases and decreases in development in the NPR-A would impact the availability of NPR-A Impact Mitigation Grant funds (money that the State of Alaska receives from federal leases that it uses to support public services and facilities) for those North Slope Borough communities located within or impacted by the NPR-A , while revenues to the North Slope Borough would impact all North Slope Borough communities whether they are located within the NPR-A or not.

The following sections describe several events with impacts to Iñupiat that have occurred in the past and could occur in the future. Because cumulative effects to subsistence resources have been discussed in detail in other sections, the reader is encouraged to read cumulative effects sections on vegetation (4.8.7.5), fish (4.8.7.7), birds (4.8.7.8), terrestrial mammals (4.8.7.9), marine mammals (4.8.7.10), special status species (4.8.7.11), subsistence (4.8.7.13), and public health (4.8.7.21).

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Activities

Prior to sustained contact between the Iñupiat of the North Slope and Euro-Americans, effects to the sociocultural systems of Native communities were primarily the result of interregional conflicts and natural factors, including weather and natural population cycles of subsistence animals. As discussed in sections 4.8.7.13, "Subsistence," and 4.8.7.14, "Sociocultural Systems," the advent of commercial whaling during the mid-19th century in the Pacific Ocean and subsequent Euro-American influence had a profound effect on the people and resources of the North Slope. Effects on the Iñupiat of the North Slope included disease, employment, introduction of new food and products, the increased availability of alcohol and tobacco, ongoing efforts to acculturate the Iñupiat through missions and government schools, and efforts to centralize and make sedentary the highly mobile populations of Iñupiat. Within decades, the whalers largely depleted the whale population and began harvesting vast numbers of walrus, causing mass starvation of Iñupiaq and Yupik Eskimos in several coastal communities that depended on these marine mammals. In addition to these impacts to subsistence, there was a concurrent decrease in the Iñupiaq population due to disease, accidents, and poor health care. Following the reduced presence of Euro-Americans in the beginning of the 20th century, the Iñupiat returned to their highly dispersed way of life, with additional emphasis on fur trapping and reindeer herding as a source of money to buy those Euro-American goods. Iñupiaq, as well as whale and walrus populations, gradually recovered during the 20th century although some whale populations, including bowhead whales, are still depressed from historic levels. See also discussions on health-related changes during this period in section 4.8.7.21, “Public Health.”

By 1950, the Bureau of Indian Affairs was requiring families with school age children to relocate to population centers (e.g., Barrow) so that the children could attend school. Job opportunities and construction of a hospital and church at Barrow also encouraged North Slope residents to settle there. Many children were sent outside to boarding schools. In Canada, the forced attendance of indigenous children at residential boarding schools during the same period is now considered an injustice that led to significant abuse and neglect and for which the government and churches have apologized and paid legal settlements. In Alaska, the smaller and less remote system was also less corrupt: it did constitute forced assimilation, but diverse Alaska Natives who met at the schools later formed the core of the Alaska Federation of Natives. Many students who returned home from boarding schools became spokespeople for their communities and interposed themselves between negative impacts of development and traditional ways of life.

Summarized histories of the Distant Early Warning Line radar system are provided in section 4.8.2.2 and in section 4.8.7.14, “Sociocultural Systems.” Construction of the Distant Early Warning Line would constitute an environmental justice issue by modern measures: land occupied by a small, disenfranchised, minority population was appropriated without consultation or notice. Although events in the 1950s cannot be judged by today’s standards, the federal government’s widely perceived failure since the 1980s to promptly or adequately address the resulting contamination of Iñupiaq land or to compensate residents for the loss of their land raises environmental justice concerns: Iñupiaq populations have borne a disproportionate share of the negative environmental consequences resulting from this federal government project.

Subsequent key events with particular relevance to environmental justice on the North Slope include Project Chariot, the Atomic Energy Commission’s plan to construct a deep-water harbor near Point Hope by detonating underground thermonuclear bombs. Although Project Chariot was eventually abandoned, studies done for it found higher levels of radionuclides in arctic residents due to atmospheric testing. Another event with significant environmental justice questions was the battle over land claims and self-determination that ensued with statehood and the discovery of oil on the North Slope that peaked with the passage of Alaska Native Claims Settlement Act.

One event that holds particular significance for North Slope Iñupiat was experimentation conducted by the Air Force’s Arctic Aeromedical Laboratory during the early 1960s involving the administration of radioactive Iodine 131 to residents of North Slope communities without their informed consent. In the 1990s, an investigation of the experiments and legal action were undertaken, resulting in compensation to numerous individuals. However, this historic event continues to be relevant for environmental justice issues and relations with the federal government today. The compensation is not seen as commensurate with the wrongdoing, and disclosure contributed significantly to fear and anger over previously held concerns about radiation and its links to cancer. It was also discovered in the early 1990s that Project Chariot scientists had secretly buried nuclear waste near the test site as part of an experiment, and this revelation built on fears over the 1988 meltdown of the Chernobyl nuclear reactor that rendered many herds of reindeer in Northern Europe inedible. The report on the iodine experiments concluded: "They no longer have faith or trust in the federal government, and feel that any atrocity might be possible in light of recent revelations" (Birch 1997).

Climate change may also be understood as an environmental justice issue because it will disproportionately affect vulnerable individuals and poor and minority populations. In many areas, the communities hardest hit by climate change are the same communities that live near fossil-fuel infrastructure. The Iñupiat of the North Slope are in a unique situation because they experience pollution and other impacts from regional oil and gas activities, because climate change impacts are more extreme in the Western Arctic than other areas, and because those impacts are particularly consequential within the context of Iñupiaq subsistence culture. Regional economic dependence on oil and gas activities does not change the environmental justice issues associated with climate change, especially because North Slope Iñupiat had no power to decide whether oil development would occur in their homeland.

Oil and Gas Exploration and Development Activities

Seismic Activities and Exploratory Drilling. Oil and gas exploration and development activities during the past century have led to a number of environmental justice issues for North Slope Iñupiat. After oil seepages and other formations were discovered by outsiders, a number of individuals and industry representatives staked mining claims on land traditionally occupied by Iñupiat. In 1923, the establishment of PET IV was effectively a government appropriation of a large tract of Iñupiaq homeland. Modern exploration, beginning in 1944, transformed the land by traversing it with tracked vehicles and tractor-drawn sled trains that created long-term scars and thermokarst; by drilling numerous test wells within; and by depositing large quantities of empty fuel barrels and other debris throughout the area.

Impacts to subsistence caused by the seismic exploration programs on the North Slope have also been observed for many years. Although seismic testing no longer uses dynamite on fish-bearing lakes, Iñupiat blamed this activity for declines in fish numbers in the vast number of interconnected lakes and streams used by subsistence fishermen. In scoping testimony for the 1998 Northeast NPR-A IAP/EIS, Arnold Brower, Jr., stated that there was consensus among Iñupiaq subsistence hunters that seismic testing, even in its modern refined form, deflects subsistence animals from the areas of operation.

Oil and Gas Development and Production. The most intense oil and gas development activity, and increased impacts to subsistence activities, occurred during the 1970s and early 1980s (e.g., development of the Prudhoe Bay and Kuparuk oil fields, construction of the Trans-Alaska Pipeline System and the Dalton Highway, and construction of a large portion of the roads, drilling pads, gravel sources, collector pipelines, and production facilities). This activity has resulted in the cumulative direct loss and indirect loss of approximately 13,000 acres and 21,000 acres of habitat, respectively, for subsistence species, and higher levels of disturbance that can impact species health, reproduction, and survivorship. Oil and gas activities also have deterred subsistence users from using their traditional subsistence use areas.

As discussed in section 4.8.7.13, "Subsistence," North Slope residents have noted the decline of fish populations caused by seismic activities, the diversion of caribou from traditional migration routes and calving areas caused by an increased number of low flying aircraft, the disruption of caribou movements by low pipelines, and the non-use of traditional harvest areas due to the avoidance of industrial areas by hunters. Oil and gas development in the Prudhoe Bay and Kuparuk areas discouraged Nuiqsut residents from using the eastern portions of their traditional harvest areas. Due to the importance of the bowhead whale and other marine mammals, many residents have been profoundly concerned about impacts to marine resources and have opposed oil development in the marine environment.

Summary of Past and Present Effects and Their Accumulation

Euro-American presence, commercial whaling, and non-oil and gas development and oil and gas exploration and development have had cumulative impacts to Iñupiaq culture and to fish and wildlife used for subsistence. Euro-American presence has impacted the Iñupiat through disease and other ills. Commercial whaling nearly decimated whale stocks in the Chukchi and Beaufort seas and the over-harvest of walrus led to hunger and starvation among coastal populations; bowhead whale populations, though recovering, remain nearly 80 percent below levels in the 1800s (Bockstoce 1986). Non-oil and gas development associated with military, residential, and commercial development have directly impacted several thousand acres of fish and wildlife habitat and have also indirectly affected habitat and animal behavior effects that have accumulated and persist today.

Sustained contact with Euro-Americans and oil exploration and development conducted by the federal government and industry have directly impacted the habitat use and behavior of subsistence species and resulted in additive impacts on subsistence resources, harvest patterns, and users. In addition, development associated with villages on the North Slope impacted subsistence resources. These activities cumulatively resulted in the loss of approximately 2,500 acres of habitat for subsistence species. These effects have disrupted subsistence livelihoods and account for some of the social problems seen in Iñupiaq villages today. The economic benefits that North Slope Borough communities have accrued due to oil revenues have greatly helped to ameliorate social problems, although dependence on an undiversified economy based on the extraction of natural resources creates other anxieties. Climate change impacts to date have caused social anxiety and climate change is increasingly understood as an environmental justice issue.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Because environmental justice for the Iñupiat is inherently tied to land use and subsistence activities, the discussion of future effects to subsistence provided in section 4.8.7.13, in the subsection "Future Effects and Their Accumulation," applies to this discussion. Non-oil and gas activities on the North Slope, including archaeological and paleontological digs, camps associated with scientific studies, recreational use, and overland moves by transport vehicles would continue to disturb Iñupiaq subsistence resources and cause users to avoid hunting in such areas while these activities are underway. Contaminated sites that persist can have long-term effects that constitute environmental justice issues. BLM anticipates that several of the NPR-A's existing military sites (Umiat Lake, Umiat Landfill, Camp Lonely, etc.) will undergo remediation efforts in the next decade. Cleanup projects could potentially have short-term effects (a "plume" created by clean-up activities) that could include a temporary increased potential for contamination of subsistence species, particularly fish, in the area around the cleanup site.

Former Distant Early Warning-Line Stations as well as the adjacent active and inactive Air Force Radar Sites and other military sites, villages, airstrips, and other non-oil and gas infrastructure are likely to persist into the indefinite future. The amount of area that would be disturbed by new development on the North Slope in villages and other public facilities is projected to double to approximately 3,600 acres by 2050 and then level off for the remainder of the 21st century. However, out-migration from North Slope villages is emerging as a major concern in the North Slope Borough. The effects of climate change are expected to become more significant in the future and it is likely that Iñupiaq communities will bear a disproportionate burden of those effects.

Oil and Gas Exploration and Development Activities

Umiat Road and Pipeline. In 2010, the State of Alaska applied for permits to construct an all-season industrial gravel road to connect Umiat in southeast NPR-A with the Dalton Highway. The Army Corps of Engineers is currently the lead agency on an EIS for the proposal and is considering several alternative routes. There are likely to be important effects on subsistence, and thus on sociocultural systems, by non-oil and gas uses of the road, which would cut across north-south migration paths and potentially affect animals in each of the Western Arctic Herd, Teshekpuk Caribou Herd, and Central Arctic Herd during some autumn and spring migration. The road would provide increased access to caribou by non-local hunters and, if hunting were not appropriately managed, this could result in cumulative mortality. Also, caribou may adapt to the presence of a road in a way that does not substantially affect the herd, but may have a substantial effect on subsistence hunters that rely on specific paths of movement by migrating caribou.

The Anaktuvuk Pass City Council, the Naqsraġmiut Tribal Council of Anaktuvuk Pass, the Nuiqsut City Council, and the North Slope Borough Fish and Game Management Committee (which includes representatives from all eight North Slope Borough communities) passed resolutions in the spring of 2011 opposing the proposed road to Umiat. The resolutions state that the threats posed by the road include increased competition for subsistence resources and public access to important subsistence rivers, most notably the Colville. The Naqsraġmiut Tribal Council's representative on the NPR-A Subsistence Advisory Panel, Andrew Hopson, reported that the main concern is that sport hunters will be able to access hunting areas along the road before the caribou herds pass over it and that these hunters could shoot at the first caribou in the herd, which is widely understood to deflect the entire herd from its migration path. As described in section 3.4.3.4 (Volume 1), Anaktuvuk Pass is particularly dependent upon caribou. Lillian Gordon of the Naqsraġmiut Tribal Council explained the council's opposition:

> This road will come at a high cost for anyone who relies on caribou and fish for subsistence. It will change everything here because more access to our hunting lands will cause serious problems to our village. This road will not help us. We have no idea why this road should be built so quickly when no one knows what will happen to our caribou (DeMarban 2011).

Although the North Slope Borough would likely gain revenue from the increased development that the road to Umiat would make possible, there appears to be widespread agreement on the North Slope that the potential economic advantages of such development do not outweigh the possible disadvantages to the subsistence lifestyle. However, another and perhaps stronger common belief on the North Slope is that development of this type is inevitable regardless of what local inhabitants' opinions may be and all efforts should therefore focus on assuring that such development has as little impact on subsistence as possible and on driving a hard bargain so that the North Slope Borough, Alaska Native Claims Settlement Act corporations, and communities derive as much economic benefit as possible. Despite economic benefits that may accrue to the North Slope Borough, significant impacts to subsistence caused by the road would represent an environmental justice issue.

Chukchi Sea Development. Offshore development in the Chukchi Sea could come ashore either on BLM-managed lands, on state lands south of Icy Cape, or on private lands, such as those owned by the village corporations of Point Lay and Wainwright. Wainwright, as an example, could be considered as an onshore hub due to its proximity to the areas of exploration, the harbor for smaller vessels provided by the Kuk River, and the fact that the village corporation owns the necessary land. In anticipation of possible use of the area for exploration and development, subsidiaries of the Olġoonik Corporation (the Wainwright village Alaska Native Claims Settlement Act corporation), have built gravel pads, an access road and a camp, and will build at least one more camp and possibly a helicopter pad to accommodate oil exploration personnel and activities. It is possible that subsidiaries of the Olġoonik Corporation could secure oil industry contracts to construct a complete new shorebase if a commercial discovery is made, and facilities would include administrative, maintenance, and housing infrastructure as well as transportation facilities that may include a marine dock along with roads connecting facilities. Future scenarios for Wainwright may include a road to the barge landing at the mouth of the river and a road to and use of the airfield and gravel pad at the nearby deactivated Distant Early Warning-Line/North Warning System radar station. Analogous infrastructure could also take place on lands close to Point Lay. If the Point Lay or Wainwright village corporation secures contracts and/or leases land for onshore infrastructure associated with offshore oil development in the Chukchi, that community will most likely experience direct economic and sociocultural impacts. The financial benefits could reduce anxiety about the community's future economic wellbeing, but anxiety could increase over population growth, negative impacts to subsistence resources and use areas, and the increased amount of industrial air and water traffic around the community.

All alternatives accommodate a corridor for infrastructure associated with offshore development in the Chukchi Sea. If a pipeline and road were built east across the NPR-A, they would have effects similar to those of the Umiat road and pipeline. The portion of that pipeline and road extending east from the NPR-A to the Trans-Alaska Pipeline System would likely have effects subsumed by (as opposed to being additive to) those of the Alpine-Kuparuk-Prudhoe Bay infrastructure or the Umiat road/pipeline.

Offshore oil and gas production in the Chukchi Sea could have additional impacts on fish that could accumulate. The permanent onshore support infrastructure associated with offshore activities would increase the extent of the anthropogenic footprint already projected to occur with NPR-A development, contributing to changes in natural drainage patterns and water quality, alterations to physical habitat, barriers to fish movements, increased water pollution, and oil spills. Causeways, docks, or other similar structures could further hinder or divert marine or anadromous fish migrations along the coast, with each coastline structure exacerbating the impact.

The support infrastructure for offshore activities could make it economically profitable to extract oil and gas reserves from areas within the NPR-A which would otherwise not be economically recoverable, causing a synergistic increase in disturbance sources within the NPR-A. In this scenario, the northern and southern areas of NPR-A could be to some degree divided by a strip of industrial development, including a network of pipelines and access roads. There is the potential for this scenario to have a major impact on subsistence resources and access to those resources. Furthermore, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a self-reinforcing system.

Beaufort Sea Development. Offshore development in the Beaufort Sea may require onshore processing facilities and would require onshore pipelines. Such facilities in the NPR-A would impact Teshekpuk Caribou Herd year round and may accumulate with other disturbances for that herd particularly during calving and insect-relief seasons. Impacts of these types during those seasons could at some point have population level effects on the Teshekpuk Caribou Herd, although it is not clear that such effects have occurred for the Central Arctic Herd under similar circumstances. This support infrastructure would also have impacts on fish that would be additive to those created by onshore oil and gas activities as described above.

Alternatively, if oil is developed in this region of the Beaufort and this plan allows it to come ashore, the distribution system from there to the Trans-Alaska Pipeline System may make it more economical to develop smaller oil and gas fields in the northeastern NPR-A. This may produce a synergism resulting in greater production from that portion of the NPR-A than foreseen under this plan's scenario individual alternative scenarios analyzed in sections 4.3.13 through 4.6.13 (Volumes 2 and 3). Moreover, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a self-reinforcing system. There is the potential for this scenario to have a major impact on subsistence resources and access to those resources and thus represent an environmental justice issue for Iñupiaq subsistence users for whom that area is critical.

The harvest of marine mammals is of central cultural importance to the Iñupiat, and offshore oil and gas production in the Chukchi and Beaufort seas has the potential to negatively impact populations of and subsistence access to marine mammals. Iñupiaq on the North Slope harvest far fewer walrus in modern times than during previous eras, thus disturbance to the walrus population from offshore oil development would not appreciably impact nutritional security. Nevertheless, the health of the walrus population is very important to the Iñupiat for many reasons, including the fact that walrus could be a significant food source in times of need. Walrus already appear to be suffering from climate change because they normally haul out, rest, and feed from the ice edge. In recent years, walrus have begun hauling out in summer on Alaskan and Chukotkan coastal areas instead, which are more distant from their core feeding grounds on the sea floor of the Chukchi. The Chukchi is particularly shallow and produces an abundance of crustacea and mollusks that are choice food for walrus, which furrow through the mud floor eating and creating habitat for more food. If that sea floor were disturbed or contaminated by an oil spill, the walrus population could suffer. Also, spilled oil tends to collect between and under breaks in the sea ice, where many marine mammals spend time. Seals and polar bears are also very dependent on this habitat and are particularly sensitive to oil spills because oiled fur cannot provide the insulation they require.

Most importantly, offshore oil activity in the Chukchi and Beaufort seas could cause whales to change their travel routes, which would make subsistence whaling more dangerous and less successful. A significant reduction in bowhead whaling would have serious and negative impacts on Iñupiaq communities, which are socially organized around whaling crews and whaling celebrations. Iñupiaq communities would therefore bear a disproportionate share of the negative environmental consequences of offshore oil and gas activities. The economic benefits that would accrue to the North Slope Borough from offshore development would mitigate those impacts but would not correct the environmental justice issue inherent in this scenario.

Commercial Gas Pipelines. Construction of gas pipelines would have short-term effects on wintering caribou if caribou are present during construction. This could affect both the Teshekpuk Caribou Herd and the Central Arctic Herd. Once buried, the pipeline would have no further disturbance effects except for brief periods of maintenance. It is anticipated that these effects would be minor. Such a pipeline is not expected to affect fish in a direct manner that would contribute to cumulative effects on fish for the region.

A much greater impact from a gas pipeline would be effects from all the gas development that a pipeline would make possible (already analyzed under all alternatives) within the NPR-A and to the east and west. Commercial gas production on the North Slope would likely result in more infrastructure in the foothills area and in the subsistence use areas of Point Lay, Atqasuk, and Wainwright, thus increasing the area that subsistence users are likely to avoid and the amount of habitat for subsistence species that may be impacted. Permanent facilities will likely compel subsistence hunters to travel further to harvest game at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Conventional Oil and Gas Development Between the Colville and Canning Rivers. Disturbance of caribou and other subsistence resources caused by additional development in this area would have additive impacts only if it occurred in areas and time periods separate from existing disturbances. Otherwise, these impacts could accumulate with those of existing disturbance. The area between the Colville and the Canning rivers represents much of the range of the Central Arctic Herd and in some winters is also an important habitat for some Teshekpuk Caribou Herd caribou. Disturbances in this area during caribou calving season would not accumulate with any similar impacts in the NPR-A because neither of those two herds calve in both areas. Permanent infrastructure in this area will likely contribute to future effects on fish that could accumulate.

Oil and gas activities in this area have already deterred subsistence hunters from using traditional hunting, fishing, and camping sites, even if they have allotments within the oil field. The continued expansion of activity and infrastructure in this area will increase the area considered off-limits by resource users, could deflect or divert important subsistence resources from their normal routes, and require users to travel further to harvest subsistence foods at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages. This represents an environmental justice issue primarily for North Slope Iñupiat, mainly residents of Nuiqsut, for whom that area is a traditionally used area.

Unconventional Oil and Gas Development East of NPR-A. Cumulative impacts from these activities would be the same as for conventional oil and gas in this area. Whether or not impacts of unconventional oil/gas would accumulate with those of conventional would depend on the time and place of the impacts.

Spills. Oil-spill contamination of subsistence foods is another important concern regarding potential effects on Native health. Effects on subsistence resources from spills on land thus far in the NPR-A have not accumulated because the spills have been small and the cleanup and rehabilitation efforts have generally been successful. However, given the magnitude of development scenarios for the NPR-A, lands to the east of NPR-A, and offshore, this situation could change. Spills associated with reasonably foreseeable future projects could potentially affect terrestrial mammals and there is an increased probability of spills entering aquatic habitats that could affect fish and marine mammals. In the unlikely event that a large spill were to occur and contaminate essential whaling areas, major effects to subsistence resources could result from the combined factors of shoreline contamination, cleanup disturbance, and disruption of subsistence practices. Increased oil and gas development in the Chukchi and Beaufort seas would increase the likelihood of spills that would enter coastal waters and impact fish and marine mammals. Spills in either environment would likely have sublethal effects on caribou and other terrestrial subsistence game, but effects on fish and marine mammals from even small individual spills in coastal waters could accumulate over time. Spills in marine environments that impact fish and marine mammals have the potential to create major negative impacts to subsistence and thus to sociocultural systems. Such impacts would have a disproportionately high effect on Alaska Natives.

Contamination of subsistence foods by oil spills would potentially affect Native health (see section 4.8.7.21, "Public Health"), and health and survivorship of subsistence species.

Abandonment. In the event of oil field abandonment, the Iñupiat would likely be employed to assist in the removal and demobilization of the infrastructure, and would continue with their subsistence pursuits. The abandonment of oil fields and the related loss of revenue would have serious effects on the entire state of Alaska. Worldwide data suggest a consistent pattern of marked increases in stress, social problems, and emigration under circumstances of sudden or severe economic depression. Data from Iñupiaq populations has shown that economic depression correlates strongly with epidemic rates of suicide (Travis 1985), and the greater dependence on the global economy today than ever before indicates that economic collapse would have serious consequences. To the extent that abandonment would disproportionally impact Iñupiaq populations economically while leaving the same people with environmental issues, including climate change, that are largely a result of the oil and gas industry, abandonment could present an environmental justice issue.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

The extent of expected cumulative effects on environmental justice issues would vary depending on the alternative selected under this IAP/EIS, although no scenario is expected to result in overall impacts that would be more substantial than those caused by technology, other aspects of modernization, and climate change. Total, long-term, direct and indirect impacts to habitat from exploration and development combined would range from 0.14 percent (Alternative B-1) to 0.29 percent (Alternative D) of the NPR-A. However, functional loss of culturally important areas due to actual avoidance zones and displacement of subsistence resources could involve a much greater area. Because the area that is most likely to be developed for oil under the alternatives (economic zones 110 and 120, section 4.2.1.2. "Discovery and Development", Volume 2) includes the most important calving and insect-relief habitat for Teshekpuk Caribou Herd caribou, impacts to subsistence users who depend on this resource could be much greater than that predicted based solely on the number of acres disturbed. Also, gas development could overlap with the habitat of the Western Arctic Herd with similar effects. Impacts to the Western Arctic Herd from management decisions within the NPR-A could affect the over 40 communities that harvest Western Arctic Herd animals. These impacts would be added to any impacts resulting from a possible road to Ambler or expansion at the Red Dog mine. If impacts to caribou and other subsistence resources accumulate, this would affect the long-term sustainability of subsistence activities and represent an environmental justice issue.

Impacts to subsistence resources and use areas on the North Slope from future oil and gas exploration are expected to be additive with respect to impacts from other past, present, and future non-oil and gas activities and past and present oil and gas activities. The impacts in the NPR-A would increase the total level of disturbance and the amount of subsistence use areas impacted by oil and gas development, and would be additive for the most part. However, if a pipeline for offshore oil is constructed across the NPR-A and this makes economic the development of additional fields which would not otherwise have been economically developable, there would likely be synergistic effects on the amount of subsistence use areas affected.

The effects to environmental justice in terms of subsistence and culturally important areas would be least under Alternatives B-1 and B-2 because much of the area where impacts could accumulate to caribou and fish would be unavailable for leasing. If the BLM chooses Alternative B-1 of this plan, it would preclude development along the entire length of the NPR-A coast from Barrow to the Nuiqsut owned lands just west of the Colville River. However, under Alternative B-1, Beaufort Sea development north of NPR-A might still occur but exclusively use offshore facilities and an offshore pipeline. This would greatly reduce the economic possibility of development in that portion of the Beaufort and the outcome would be fewer disturbances for fish, caribou, and other terrestrial mammals. Alternatives B-1 and to a lesser extent B-2, which would make the least amount of land available for leasing, could result in a lower revenue stream for the North Slope Borough, which could represent a negative sociocultural impact. The effects to subsistence could be greatest under Alternative D, since the entire NPR-A would be open to leasing with fewer mitigations than under other alternatives. Revenues to the North Slope Borough from oil would increase if many leases were sold under Alternative D.

The Iñupiaq people, a recognized minority population and the primary subsistence users on the North Slope, will be affected by future disturbances to key subsistence species that leads to disruption, displacement, or long-term changes in species' populations. Expanded oil and gas development on the North Slope, on both federal and State leases, would increase disturbance effects to subsistence species and harvest patterns. While each individual project would likely be a small incremental increase, the cumulative effect would eventually become more and more repressive to the subsistence lifestyle.

Conclusion

Key events in North Slope Iñupiaq history that are relevant to a discussion of environmental justice include the severe subsistence hardships and starvation caused by the Yankee whalers' over-harvest of bowhead whales and walrus in the Arctic Ocean, various instances of forced assimilation, the construction of military sites on traditional land and contamination of that land, the Iodine experiments, early oil exploration in the NPR-A, the battle for land claims, and the particularly severe impacts of climate change in the western Arctic.

In addition to direct and indirect loss of habitat that can affect subsistence species, noise and other disturbance associated with oil and gas development would divert, deflect, and disturb subsistence species, potentially having population-level effects that would accumulate. Oil and gas development could also affect subsistence harvest by causing subsistence hunters to avoid certain areas. During the past several decades, populations of caribou, bowhead whales, and other wildlife and fish have generally increased, to the benefit of subsistence hunters, despite habitat, disturbance, and other effects that have accumulated. Climate change could cause changes to the environment of the North Slope that could affect subsistence resources and users, as discussed in section 4.8.7.13, "Subsistence." The reduction of sea ice has exacerbated coastal erosion, the weather has become less predictable, the shore ice in spring is less stable for whaling, fall travel for caribou is hampered by a late and unreliable freeze up, ice cellars provide less reliable food storage, and the number of marine mammals that are experiencing habitat loss is apparent. All of these issues create significant concerns for the Iñupiat because they are perceived as factors that cannot be controlled and that are threatening their way of life. The substantially greater economic stability brought by oil development on the North Slope has helped mitigate much of the stress commonly associated with poverty and other issues in recently settled indigenous populations but does not remove issues of environmental justice.

4.8.7.16 Recreation Resources

This section discusses recreation resources as they relate to the cumulative effects development scenarios described in sections 4.8.1 to 4.8.3

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Sections 4.8.2 on page 4 of this volume and 4.2.1.1 in Volume 2 describe activities not associated with oil and gas exploration and development on the North Slope. Activities such as archaeological collection efforts, field camps, survey work, scientific research, film permits, and overland moves on lands outside of the planning area would have minimal temporary or short-term impacts to recreation resources within the NPR-A. Temporary structures such as tents, vehicles such as Rolligons, and noise from generators, aircraft, human presence, and associated activities could have some minimal seasonal impacts on the setting, experiences, and desired beneficial outcome from use of public land. Because all of these identified non-oil and gas activities would be transitory and seasonal, the likelihood of recreationists encountering them in any given location in the 22.6-million-acre planning area is small.

The previous and current growth of communities around and within the NPR-A may have a negligible impact on recreation resources through competition for resources on public lands. However, the Special Recreation Permits that the BLM has issued have not involved lands around a village.

The past use of lands for military development, such as the former Distant Early Warning-Line Stations as well as the adjacent active and inactive Air Force Radar Sites, does not take away from recreation opportunities within the Reserve. However, they are in various stages of reclamation and use (see section 4.8.2.2) and at present generally not available for use by recreationists.

Oil and Gas Exploration and Development Activities

Some past oil and gas exploration activity resulted in gravel pads and runways that remain today and can be beneficial for recreationists. For example at Ivotuk, outside but near NPR-A, a gravel pad and runway remain from past oil and gas activity. Some SRP holders that use the Utukok River have their clients flown to Ivotuk from Fairbanks. From Ivotuk they are picked up by a small plane and flown to a site on the Utukok to start their trip. At the end of the trip, the clients are picked up by the small plane and flown back to Ivotuk for transport back to Fairbanks.

Past oil and gas activities have left drums and other debris in the Reserve. The impact on a recreationist would be for the duration that it is in view.

Summary of Past and Present Effects and Their Accumulation

The impacts to recreation resources and use from past and present activities are negligible. Past activities in the NPR-A have left some mark on the land that can detract from the recreation experience. However, this evidence of past use is scattered and localized and affects a very small proportion of the nearly 23-million-acre Reserve. As in the past, recreation use in the NPR-A is minimal although there has been an increase in the last five years in permits. In 2005, there were seven authorized Special Recreation Permits in the planning area compared to ten in 2010.

Future Effects and Their Accumulation

Future effects to recreation resources could be both positive and negative.

Activities Not Associated With Oil and Gas Exploration and Development.

In the future, after reclamation has taken place on past military development sites, there may be remaining gravel runways and pads that could be used to access sites and to camp which could benefit recreationists and other activities such as research. Nevertheless, this could lead to competition among user groups for this resource.

The Arctic National Wildlife Refuge issues permits for commercial recreation and air transporters. In 2009 they issued 39 permits[6], compared to the 5 that BLM issued for the NPR-A. If the number of permits that were issued for Arctic National Wildlife Refuge were reduced or if recreationists are displaced by overcrowding that could mean more use of the NPR-A for recreation.

Oil and Gas Exploration and Development Activities

It is unknown where oil and gas development would be located in the NPR-A. If it were dispersed throughout the Reserve, it would have a larger impact on recreation resources than if it was concentrated. However, the areas that are currently predominantly used by Special Recreation Permits holders (i.e., southern NPR-A) would continue to be unavailable for leasing in all alternatives except Alternative D. There has been some use of the Colville River and the Umiat area for Special Recreation Permits. These areas are currently open for oil and gas leasing and would remain open in all alternatives. Associated aircraft use in support of future oil and gas activities could have a cumulative effect and negative impact on recreation experiences, by interrupting solitude and dispersing wildlife. Currently, aircraft use is minimal over the southern portion of the Reserve. Umiat has an airstrip with aircraft traffic and associated sights and sounds. If production were to take place in the NPR-A in the Umiat area, or outside of the NPR-A the airstrip would have the potential for increased use.

If a road were built to Umiat, it could have a complex impact on recreation (see "Road and Pipeline between Umiat Area and Dalton Highway" in section 4.8.3.2). A benefit would be improved access to the Reserve by driving and not flying, which would allow more people access to NPR-A. The negative impact would be that more people would have access, which could create user conflicts, impact solitude, and disperse wildlife. Chukchi Sea oil and gas development could cause minor impacts to recreation uses (see "Chukchi Sea Exploration and Development" in section 4.8.3.2). The impact would depend on the location of any facilities associated with the development. The route of a pipeline and possible road corridor is unlikely to cross areas typically used by recreationists with the exception of part of the Colville River, including the Umiat area. There could be increased use of the Umiat area for recreation if a road associated with a pipeline went from Umiat through the Reserve to the coast. There could also be a corresponding increase in recreation throughout the Reserve due to the presence of a road and the ability to have access where currently access is solely by air, if the road was open to use by the public. When Chukchi production is complete, the road might remain available for access to the Reserve. Conventional oil and gas development in the Colville-Canning Area could have an effect on recreation activity in the Umiat/Colville area (see "Conventional Oil and Gas Development in the Colville-Canning Area" in section 4.8.3.2). The airstrip at Umiat could have increased air traffic and reduction in solitude for recreation users. An oil spill or gas leak would displace recreationists if it occurred at a location that recreation activities were planned to take place. The effect would last as long as it took to remove the spill from the site.

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[6] http://arctic.fws.gov/pdf/pureportap2010.pdf accessed Nov 3, 2011

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

More oil and gas activity would occur under Alternative D than under the other alternatives. This combined with the possible Chukchi Sea development, road to Umiat and oil and gas development in the Colville-Canning area could cumulatively displace or affect recreation resources more than the other alternatives. There could be more oil and gas activity with restriction on recreation around oil fields and pipelines. Alternative B-1 would cumulatively impact recreation resources the least as it would offer the least amount of acres for leasing and would nominate 12 rivers as Wild and Scenic Rivers. Moreover, Alternatives B-1 and B-2 would make unavailable for oil and gas leasing large portions of the southern part of NPR-A where recreation use and opportunities are highest. Alternative A would not add any new areas available for leasing. Alternative C would nominate three rivers as Wild and Scenic Rivers and allow 17.9 million acres available for leasing which could affect recreation resources by displacement or intrusion of solitude and the displacement of wildlife.

Conclusion

Currently recreation use in the NPR-A is minimal although there has been an increase in the last five years in permits. In 2005, there were seven authorized Special Recreation Permits in the NPR-A compared to ten in 2010. The impacts to recreation resources from past and present activities are negligible. Future oil and gas activities, the road to Umiat and associated activity, the Chukchi Sea development, and the alternatives found in this IAP would have an additive cumulative effect on recreation resources in the NPR-A. Also in the future as the climate gets warmer, the timing and location of recreation activities could change. For instance if wildlife change the areas that they inhabit then both wildlife viewers and hunters would correspondently change the location that they recreate. Cumulatively there would be more activity, more human presence, increased noise, increased aircraft use, change in location of recreation activities, and correspondingly greater impacts on the setting, experiences, and desired beneficial outcome from use of public land.

4.8.7.17 Wild and Scenic Rivers

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Past and present non-oil and gas impacts to wild and scenic river values are minimal within NPR-A. There is some subsistence, research, and recreational use of eligible rivers, but impacts to outstandingly remarkable values have been negligible.

Oil and Gas Exploration and Development Activities

Past oil and gas exploration has left a mark on lands adjacent to several of the eligible rivers in the planning unit. There is a hut and drum dump at Brady on the Kaligwa; and an airstrip, drums, a Rolligon, and other debris are visible along the Utukok. Drums from surveys and mobilizations are sparsely strewn throughout NPR-A. If the Utukok or Kaligwa were found suitable and managed as wild or scenic river areas, the drums and debris would be incompatible, and would be removed subject to availability of funding following the principle of maintaining and enhancing the recreational values.

It should be noted that current practice in exploration and development is much improved and impacts as described above would be highly unlikely to occur in the future. No ongoing or potential impacts to NPR-A rivers have been identified from oil and gas activities to the east of NPR-A.

Summary of Past and Present Effects and Their Accumulation

The lingering impacts of past activities on wild and scenic river values in the planning unit are more noticeable than present activities. The primary effects are an accumulation of debris and drums, especially along the Utukok. Present subsistence and recreational uses along eligible rivers are largely not impacting river values in a negative way. Subsistence is an outstandingly remarkable value of the Utukok River and Carbon Creek, so improvements to subsistence access from past activities such as trail cutting, hut construction, and materials left over from past exploration could be considered to have enhanced river values along these streams.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

There are no components of the national Wild and Scenic Rivers System within NPR-A. At this time, the only wild and scenic river on the North Slope is the Ivashak within the Arctic National Wildlife Refuge. However, during the preparation of their draft Comprehensive Conservation Plan, the Arctic Refuge made preliminary suitability determinations for 10 eligible rivers, and found that the Atigun River, Marsh Fork Canning River, Hulahula River, and Kongakut River within the Refuge were suitable for management as Wild and Scenic Rivers. These Refuge rivers are more heavily used for recreation than the eligible rivers within NPR-A, and human impacts are a concern to refuge management. (U.S. Fish and Wildlife Service 2011).

It is possible that recreational use could reach levels within the Arctic Refuge that would displace recreational users from the refuge either from loss of social benefits due to crowding or from management actions to limit this use. If this were to happen, use could increase on NPR-A rivers, particularly remote rivers flowing from the Brooks Range before they reach the coastal plain. All 12 eligible rivers considered in this IAP would potentially receive displaced recreation users seeking similar social benefits to those they would accrue from river trips in the Arctic Refuge.

If an eligible river in NPR-A is not found suitable, and if recreational use increases more rapidly than expected, then there would be no mandate to protect remote river recreation experiences as outstandingly remarkable values. While recreational values would be considered and preserved where practical, management would also be focused on protecting other important surface resource values, especially subsistence and special status species.

Oil and Gas Exploration and Development Activities

It is possible that a road to Umiat would increase recreational use on the upper Colville and its tributaries because it would decrease the expense of demobilizing from river trips. It is also possible that motorboat traffic on the Colville could extend from an Umiat road upstream and beyond the point where the Colville is managed as part of NPR-A. This would change the character of the social benefits for recreational users of the upper Colville, moving from a very remote experience where the visitor is unlikely to see another party or even human footprints or a fire ring, to one where the presence of other parties is more apparent.

It is unlikely that a pipeline from the Chukchi Sea across NPR-A would significantly impact river values along eligible rivers. Such a pipeline would not be likely to impact rivers in the foothills with outstandingly remarkable recreational values. A spill might impact water quality in an eligible river previously found to be not suitable.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Under Alternatives B-1 and C, some rivers would be managed to protect and enhance outstandingly remarkable recreational values. Under Alternative B-2 the standard, in the form of a management commitment, would be to protect the outstandingly remarkable recreational values to preserve eligibility, a slightly less restrictive standard than to protect and enhance. If recreational use of rivers recommended for designation increased in response to technical innovations, crowding in the Arctic National Wildlife Refuge, or improved road access, then NPR-A management would have a mandate to protect and enhance the opportunities for primitive recreation in these areas. Under Alternative B-2, some minor impacts to recreational values could be allowed. Under Alternatives A and D, there would be no such mandate or management commitment, and increased recreational use would be accommodated so long as the Naval Petroleum Reserves Production Act direction for an expedited program of leasing and protection of surface resources, and the responsibility to protect subsistence resources and access, can be met.

Conclusion

Past cumulative impacts to wild and scenic river values are mainly in the form of signs of oil and gas exploration. Present cumulative impacts are negligible. Identified cumulative impacts that could occur in the future are due to factors such as crowding in the Arctic

Refuge or improved access to Umiat, which could lead to significantly increased impacts from recreational use, particularly on the Utukok, the upper Colville, and the north-flowing tributaries of the Colville. It is unlikely that any of these impacts would significantly affect the eligibility of any rivers in the area for future designation as components of the national Wild And Scenic Rivers System.

4.8.7.18 Wilderness Characteristics

This section discusses wilderness characteristics as they relate to the cumulative effects development scenario described in sections 4.8.1 to 4.8.3. Wilderness characteristics are defined in Section 2(c) of the Wilderness Act (see section 3.4.8) and consist of size, naturalness, and outstanding opportunities for solitude or primitive and unconfined recreation. They may also include supplemental values. None of the scenarios would affect the size of wilderness in the NPR-A, therefore size is not discussed in this analysis.

Past and Present Effects and Their Accumulation

Past and present activities outside of villages and Umiat, which are not on BLM managed lands, have not negated the wilderness characteristics of naturalness, outstanding opportunities for solitude or primitive and unconfined recreation on the NPR-A lands.

Activities Not Associated With Oil and Gas Exploration and Development

Sections 4.8.2 on page 4 of this volume and section 4.2.1.1 (Volume 2) describe activities not associated with oil and gas exploration and development on the North Slope. The characteristics of wilderness could be affected on a seasonal basis by present on-the-ground activities such as archeological collection efforts, field camps, survey work, scientific research, recreation activities, film permits, and overland moves. However, at the current level of activity the impact of these activities to wilderness characteristics would be minimal to most observers, due to the size of the planning area, the temporary nature of the activities, and the limited human intrusion. Past non-oil and gas activities have not altered wilderness characteristics in the reserve.

The previous and current growth of communities around and within the NPR-A have had an impact on the wilderness characteristics of naturalness and outstanding opportunities for solitude or primitive unconfined recreation. The villages all have roads, infrastructure and inhabitants which negate these wilderness characteristics within their boundaries. Outside of their boundaries, it is possible to still have these characteristics.

The past use of lands for military development, such as the former Distant Early Warning-Line Stations as well as the adjacent active and inactive Air Force Radar Sites, does detract from wilderness characteristics of naturalness, and outstanding opportunities for solitude or primitive and unconfined recreation. The impacts are localized and site specific; the sites are in various stages of reclamation and use, see section 4.8.2.2. The sites within the planning area occupy a small portion of the total planning area and do not negate wilderness characteristics of the Reserve. See Table 4-35 on page 8 for acreages that are known.

Oil and Gas Exploration and Development Activities

Previous seismic activities have created long lasting impacts to vegetation (see section 4.3.5, Volume 2) which have impacted naturalness and scenic values. The color contrast would be minimal from ground view and almost nonexistent from more than a few hundred feet away. After 8 to 9 years, the evidence of use would be minimal. Seismic operations by their nature do not follow the same routes every year and the number of miles of survey line run can vary greatly from year to year. There are existing remnants of use on the landscape from oil and gas activity prior to the 1998 lease sale (see section 3.2.11, Volume 1, on Legacy Wells). As funding becomes available, the BLM is plugging old wells, cleaning sites and removing debris. Oil and gas activity since the 1998 lease sale has included requirements that leaseholders reclaim an area once they have completed their activity on the land. Currently there are three wells that have been capped for future re-entry. However, they only occupy a minimal space on the landscape, approximately an impact of six by six feet. The impacts on wilderness characteristics from these activities are minimal, not permanent and confined to the immediate area of use. Oil and gas activity outside the reserve does not alter the wilderness characteristics of the reserve.

Summary of Past and Present Effects and Their Accumulation

Past and present use of the reserve has not negated wilderness characteristics of the reserve.

Future Effects and Their Accumulation

The analysis period covered by this section ends in the year 2100.

Activities Not Associated With Oil and Gas Exploration and Development.

On-the-ground activities such as archeological collection efforts, field camps, survey work, scientific research, recreation activities, film permits, hazardous and solid material removal and overland moves would continue for some amount of years. If future oil and gas activities avail recreationists to easier access to the reserve this type of activity could increase. However, it is unlikely that it would increase to the point of altering the wilderness characteristics of the reserve.

Reclamation activities on past military development, former Distant Early Warning-Line Stations and other Active/Inactive Air Force Radar Sites will continue to occur and would result in temporary impacts to wilderness characteristics of naturalness, solitude and unconfined primitive recreation. Once the sites are reclaimed these characteristics could return, although the sites may have remaining gravel runways and pads that could entice the public to use these sites for recreation activities outside of the purview of BLM permitting. If it is determined in the future that these activities impair wilderness characteristics the areas would be excluded from the Lands with Wilderness Characteristics Inventory

By the year 2100 villages within the reserve may have an increase in population and infrastructure (see section 4.8.1.2). Since the increase would be contained within the village it would not alter the wilderness characteristics of the BLM-managed lands within the reserve.

Oil and Gas Exploration and Development Activities

Impacts on wilderness characteristics from oil and gas production activities would be long-term. If it is determined in the future that these activities impair wilderness characteristics the areas would be excluded from the Lands with Wilderness Characteristics Inventory Prudhoe Bay, Kuparuk and Alpine oil and gas activity occurs on lands managed by the State of Alaska. Activities on these lands would not detract from wilderness characteristics in the Reserve. However, supplemental values could be affected if there was a change in wildlife patterns.

If a road were built to Umiat it could have a long-term impact to the wilderness characteristics of the Reserve (see " Road and Pipeline between Umiat Area and Dalton Highway" in section 4.8.3.2). If the road were open to the public this would be the first time that they would be able to drive to the reserve. That by itself could entice people to drive to Umiat to get what could be for many, the first real look at the NPR-A. Once at Umiat, which is State land, they would have access to the Colville River and could access NPR-A by motorized boat or snow machine (depending on season). This could have a negative synergistic impact on the wilderness characteristics of solitude or primitive unconfined recreation.

A Chukchi Sea development could have an impact on wilderness characteristics (see section 4.8.3.2). If the associated gravel road and pipeline were to cross the NPR-A and detract from the area's naturalness and if there were associated noise and activity that detracted from the natural environment it would have a negative impact. There could be increased use of the Umiat area if a road associated with a pipeline went from Umiat through the reserve to the coast.

A Beaufort Sea development could have an impact on the wilderness characteristics (see section 4.8.3.2). The scenario depicts the possibility of 18 helicopter flights a week. This would impact the wilderness characteristics of solitude and primitive recreation experience in the area of the development, and helicopter routes.

Conventional oil and gas development in the Colville-Canning Area could have an effect on wilderness characteristics in the Umiat/Colville area (see section 4.8.3.2). There could be increased air traffic at Umiat, which would result in a reduction in solitude and primitive recreation experience for recreation users in the reserve. An oil spill or gas leak could cause a reduction in aesthetic value and naturalness associated with visible sheen and residues on vegetation and water. The effects on wilderness characteristics would depend on the ability to restore the area to its natural environment.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Most oil and gas activity would occur under Alternative D, as this alternative would allow 100 percent of the reserve to be leased. This combined with the possible Chukchi Sea development, Beaufort Sea development, the road to Umiat, and additional development in the Colville-Canning Area could cumulatively impact wilderness characteristics in the reserve more than the cumulative effects under the other alternatives. Alternative B-1 would result in the least amount of cumulative impacts to wilderness characteristics because it would offer the fewest amount of acres for leasing and would nominate 12 rivers as Wild and Scenic Rivers. Moreover, Alternative B-1 would make unavailable for leasing large portions of the southern part of NPR-A where recreation use and opportunities for access to lands with wilderness characteristics is highest, as would Alternative B-2. Alternative A would not add any new areas available for leasing. Alternative C would nominate three rivers as Wild and Scenic Rivers and allow 17.9 million acres available for leasing which could affect wilderness characteristics by the intrusion of solitude and a primitive and unconfined recreation experience. With the exception of Alternative D, the southern portion of the reserve would remain as unavailable for leasing thus protecting wilderness characteristics.

Conclusion

The wilderness characteristics of naturalness, outstanding opportunities for solitude or primitive and unconfined recreation have been minimally diminished within the Reserve by past and present non-oil and gas activity. Future activities not associated with oil and gas exploration and development could temporarily impact wilderness characteristics. Past and present oil and gas activity has impacted wilderness characteristics minimally, temporarily and in the immediate area of use.

In the future, supplemental values of ecological, geological, or other features of scientific, education, scenic, or historical value to wilderness characteristics may be affected if the climate continues to warm in the NPR-A (Scenarios Network for Alaska Planning 2010). See climate sections within the “Physical Environment” and “Biological Resource” sections for more information.

Impacts to wilderness characteristics by a possible road to Umiat, Chukchi Sea development, Beaufort Sea development and conventional oil and gas development in the Colville-Canning Area along with oil and gas exploration and development in the NPR-A cumulatively would be greater than impacts from each singularly.

4.8.7.19 Visual Resources

This section discusses visual resources as they relate to the cumulative effects development scenario described in sections 4.8.1 to 4.8.3.

Past and Present Effects and Their Accumulation

Activities Not Associated With Oil and Gas Exploration and Development

Sections 4.8.2 on page 4 of this volume and section 4.2.1.1 (Volume 2) describe activities not associated with oil and gas exploration and development on the North Slope. Past and present activities such as archeological collection efforts, field camps, survey work, scientific research, recreation activities, film permits, and overland moves are seasonal therefore the casual observer has been minimally impacted. The size or scale of a particular project has been minimal. Most of the activities would take place during the summer when there is a prevalence of daylight, allowing activities to be seen from a farther distance than winter activities. Lights from equipment used during winter activities, such as overland moves would be the only visual winter site due to limited daylight hours. The lights on the equipment would only be visible while the equipment is passing through. The likelihood of a casual observer being near is practically nil in the winter. However, winter overland moves, such as overland transportation of fuel and supplies to villages, could leave long lasting impacts to vegetation (see section 4.3.5, Volume 2). The contrast has been minimal from ground view and almost nonexistent from more than a few hundred feet away. After 8 to 9 years, the evidence of use would be minimal.

Landscape modifications from previous and current growth of communities around and within the NPR-A, the past use of lands for military development, such as the former DEW Line Stations as well as the adjacent active and inactive Air Force Radar Sites have impacted visual resources or scenic quality, by creating a contrast to the landscape character elements of form, line, color, and texture of a primarily horizontal natural landscape. The facilities introduce vertical blocky regular shapes and lines to an irregular horizontal landscape and the smooth texture contrasts with the varied textures of the windswept terrain and irregular texture of vegetation.

The colors of structures and equipment associated with non-oil and gas activities contrast with the white color of the snow-covered landscape and the various hues of greens and browns. Other buildings found throughout the North Slope are cabins and camp structures associated with subsistence activities. These structures are usually isolated single-story small plywood cabins that produce some contrast with the surrounding landforms, but on a very local scale, along lakes, rivers, and creeks.

Airstrips are located within the Reserve and also villages, oil and gas fields, and Deadhorse. While the profile of an airstrip is low, landform changes are introduced by brown colors in predominantly green vegetation and more regular lines than the surrounding irregular vegetation.

Oil and Gas Exploration and Development Activities

Previous seismic activities have created long lasting impacts to vegetation (see section 4.3.5, Volume 2) which have created a weak contrast to form, line, color, and texture of a primarily horizontal natural landscape. The color contrast has been minimal from ground view and almost nonexistent from more than a few hundred feet away. After 8 to 9 years, the evidence of use is minimal, although activity prior to the completion of the 1998 Northeast NPR-A IAP/EIS had longer affects. Seismic operations by their nature do not follow the same routes every year and the number of miles of survey line run can vary greatly from year to year.

Oil and gas activity prior to the 1998 lease sale left remnants (drums and other debris) of use on the landscape. As funding becomes available, the BLM has been plugging old wells, cleaning sites, and removing debris. However, debris not located at old well sites are scattered in the NPR-A. As the BLM encounters these items, GPS points are taken so that debris eventually may be able to be removed. The debris is a contrast to the landscape character elements of line, form, color, and texture of the landscape. Some past oil and gas exploration activity resulted in gravel pads and runways that remain today. While the profile of an airstrip is low, landform changes are introduced by brown colors in predominantly green vegetation and more regular lines than the surrounding irregular vegetation. Due to the size of the Reserve, these items are not likely to be seen by the casual observer.

Oil and gas activity since the 1999 lease sale has included requirements that leaseholders reclaim an area once they have completed their activity on the land. There are some wells that have been capped for future re-entry. However, they only occupy a minimal space on the landscape, approximately an imprint of 6 by 6 feet.

Summary of Past and Present Effects and Their Accumulation

There have been impacts on visual resources from past non-oil and gas activities. The impact has been minor and short term with the exception of vegetation contrast resulting from winter overland moves where the impact has lasted between 8 and 9 years. Seismic activity has created the same type of impact as overland moves. There are remnants and debris of oil and gas activity in the Reserve that have a minimal effect on visual resources, mainly due to the size of the Reserve. Activities that occurred within the Foreground-Middleground Zone of the viewshed likely attract the attention of the casual observer, however due to the remoteness of the Reserve, there are limited numbers of casual observers.

Future Effects and Their Accumulation

Visual resources could be affected by future activities both within and outside of the NPR-A.

Activities Not Associated With Oil and Gas Exploration and Development

Activities not associated with oil and gas exploration would continue as they have in the past. The impacts would be expected to be similar to current impacts, minimal and temporary with vegetation impacts from overland moves lasting about 8 to 9 years.

Oil and Gas Exploration and Development Activities

Future seismic and exploration activities would tend to have similar visual impacts as those described in the past and present activities. Production activities would have a greater effect than what has already taken place. They would be moderately impacted long-term and confined to the area of view. Winter drilling requires lighting, which creates a visual contrast against the dark night sky. The casual observer is not likely to be present in the Reserve in the winter to be impacted by the light. The actual effects would depend greatly on where development fields were located. However, it is likely for production activities that areas would be off-limits to the public. Prudhoe Bay, Kuparuk and Alpine oil and gas activity occurs on lands managed by the State of Alaska. Activities on these lands could affect visual resources in the Reserve, although the distance from the Reserve would make the impact negligible.

Visual impacts from oil and gas development activities would continue to become more noticeable as production pads, staging areas, central processing facilities, gravel roads, gravel mine sites, airstrips, and pipelines change the landscape. In many areas, the increase in development would change the existing landscape from a very natural viewshed to a more industrialized setting introducing vertical lines, regular patterns, and varied colors.

A road and a pipeline between Umiat and the Dalton Highway and conventional oil and gas development in the Colville-Canning area could affect visual resources if they led to increased activities, such as those discussed above that alter the landscape within the

Reserve. A Chukchi Sea or Beaufort Sea development would impact visual resources by contrasting the landscape character elements of line, form, color and texture of the landscape within the area of use that is visible by the casual observer within the NPR-A. If a road to Umiat or Chukchi Sea or Beaufort Sea development led to additional oil and gas development in the NPR-A, this development would have impacts to visual resources similar to those described for development resulting from the alternatives of this plan. An oil spill or gas leak could impact visual resources from any visible residue and the resulting damage to underlying vegetation. The effect would last as long as it took to remove the spilled material from the site.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

More oil and gas activity would be allowed to occur under Alternative D compared to the other alternatives. This combined with the possible Chukchi and Beaufort Sea development, the road to Umiat and the Colville-Canning oil and gas development could cumulatively impact visual resources more than the cumulative effects under the other alternatives. There could be more oil and gas activity with restriction on public entry around oil fields and pipelines. Alternative B-1 would cumulatively impact visual resources the least as it would offer the least amount of acres for leasing and would nominate 12 rivers as Wild & Scenic Rivers. Moreover, Alternative B-1 would make unavailable for leasing large portions of the southern part of NPR-A where recreation use and opportunities are highest and hence where the casual observer would visit, as would Alternative B-2. Alternative A would not add any new areas available for leasing. Alternative C would nominate three rivers as Wild and Scenic Rivers and allow 17.9 million acres available for leasing which could affect visual resources more than the current level of activity taking place in the Reserve.

Conclusion

Past and present activities have had an effect on visual resources and the casual observer has been impacted during the life of a project. Most of the North Slope and planning area are still primarily a natural landscape where humans have not substantially changed the scenic quality. However, some areas have been modified by human activities. Landscape modifications from previous and present activities have impacted visual resources or scenic quality. Seismic activities could continue to create a weak contrast to form, line, color, and texture of a primarily horizontal natural landscape. Oil and gas exploration and production activities would continue to have a visual impact on the casual observer, although due to the remoteness of the Reserve, the number of casual observers is limited. Climate change could affect visual resource values by altering the current conditions of color, vegetation, land formation, adjacent scenery, and the presence of water. Shifts in public sensitivity could occur as well. Cumulatively all of the possible future activities would have an effect on visual resources. The extent of the effect would depend on the timing, location and length of time the activity took place. It is expected, however, that these impacts would be greatest within the Foreground-Middleground Zone of the viewer. Some facilities may be visible from the Background Zone and Seldom Seen Zone in areas in low elevational change or if viewed from an elevated position.

4.8.7.20 Economy

This section addresses the cumulative effects of past, present, and future activities on the market economy of the North Slope and the state of Alaska using three primary indicators of North Slope Borough revenues, jobs, and to a lesser extent, per capita income. The reader is advised to refer to section 4.8.7.13, “Subsistence” for the primary discussion of cumulative effects on the subsistence economy. Key events or factors are described, followed by an analysis of these events, and a discussion of the trends that have affected the economy and are expected to continue into the future.

Past and Present Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Historically, commercial whalers entered the Chukchi and Beaufort seas in the 1850s, pursuing whales for oil and baleen. Whaling captains hired North Slope Natives as crew members and eventually these Natives became captains of their own ships. In the 1890s, the Bureau of Education introduced reindeer into the region, providing additional food for the herders and cash for meat sold to whalers and others. By 1915, the over harvest of bowhead whales and the development of substitutes for baleen and whale oil led to the end of commercial whaling.

By the time commercial whaling ended, the cash economy was well integrated into the North Slope economy and new sources of income were needed to compensate for the loss of whaling income. Trapping became an important source of income for the region until the Great Depression brought a substantial decline in demand for furs. In the mid to late 1920s, the caribou populations crashed and the bands of Iñupiat living in the Brooks Range dispersed to other areas, not returning to the mountains until the late 1940 and 1950s.

World War II began the development of airports around the state, and North Slope residents were involved as Army Scouts. After World War II, the International Whaling Commission was established and the U.S. Navy built its Arctic Research Laboratory near Barrow. The Navy also began its early petroleum exploration on the North Slope. Both of these activities provided steady employment in the region. As the Cold War evolved, and the threat of nuclear war emerged, the Department of Defense began to build the Distant Early Warning-Line radar stations along the Alaska coastline from 1955 to 1957. This construction activity and operations provided some employment for local residents. Alaska became a state in 1959, and by 1962, a Memorandum of Understanding was signed to transfer Bureau of Indian Affairs schools to the State; however, many Bureau of Indian Affairs schools continued to exist in the state until the early 1980s.

Oil and Gas Exploration and Development Activities

As pointed out by the National Research Council (2003), the discovery of oil in 1968 at Prudhoe Bay "accelerated political processes for resolving complex issues of land tenure and rights." The Alaska Native Claims Settlement Act established the Arctic Slope Regional Corporation and the village corporations in 1971, and led to the formation of the North Slope Borough in 1972, as well as the resettlement of the villages of Nuiqsut in 1973 and Atqasuk in 1974. The Dalton Highway opened in 1974, and the first oil to flow down the Trans-Alaska Pipeline System in 1977. This provided a wealth of revenues to the State of Alaska and the North Slope Borough, with the first Permanent Fund Dividends paid to residents of the state in 1982.

Oil production at the Prudhoe Bay field peaked in 1988. Production from the Kuparuk field started in 1990 after there was sufficient capacity in the Trans-Alaska Pipeline System to accept more oil. The petroleum industry had limited exploration success after the early discoveries (in the late 1960s and early 1970s), until the discovery of the Alpine field in 1995. Alpine, located near the eastern boundary of the NPR-A, represented a new geologic concept for oil reservoirs on the North Slope and provided further impetus for opening the Reserve to exploration to private companies.

Revenue. Property tax receipts by the North Slope Borough grew from almost nil in 1975 to a peak of about $250 million in the mid-1980s, then dropped until the late 2000s. These are currently just under $276 million (2010). State of Alaska general fund petroleum revenue was $25.4 million in 1959, 12 percent of total revenues. The proceeds are estimated at $6.6 billion for 2011, about 92 percent of unrestricted general fund revenue (Alaska Department of Revenue 2011). North Slope Borough revenue, State revenue and federal revenue are presented in section 3.4.11.5 (Volume 1).

Aside from the petroleum industry, the North Slope Borough is the dominant economic organization on the North Slope. The North Slope Borough taxes onshore oil and gas facilities and uses the revenues to provide education and a wide array of other public services within its boundaries. Property taxes on oil and gas infrastructure provide over 82 percent of the total revenues received by the North Slope Borough in 2009. The value of the infrastructure is based on the estimated value of the profits that can be generated with these facilities. As the amount of oil reserves remaining in the ground declines over time, the value of the facilities also diminishes, with a subsequent reduction in the property taxes generated. The North Slope Borough uses its tax authority to issue bonds used for capital improvement projects and pledges future revenues to pay for these projects. The North Slope Borough must meet its debt service requirements on these bonds even if oil and gas property taxes decline or are eliminated at the end of Trans-Alaska Pipeline System operations, thus the result can be a substantial decline in operating budgets as tax revenues diminish. Adding reserves and infrastructure for new onshore and offshore development slows or reverses the decline.

The Trans-Alaska Pipeline System was constructed to transport Prudhoe Bay oil to market. Prudhoe Bay and Kuparuk were the largest and second-largest fields discovered in North America. Even though these fields are in decline, they still produce a significant portion of the oil on the North Slope. Production declines have already required changes to pipeline infrastructure, and resulted in increased costs per barrel of oil. Further declines will eventually result in North Slope oil resources becoming uneconomic to produce. At that time, the Trans-Alaska Pipeline System is expected to be dismantled, which will make it unlikely that additional oil will be extracted from the North Slope. With the declines in existing fields, new development and production is required to extend the useful life of the Trans-Alaska Pipeline System.

Recent lease sales have been completed in Beaufort Sea (Beaufort 195, Minerals Management Service 2005 and State of Alaska 2006, 2006A, 2007, 2008, 2010, 2010A), the Chukchi Sea (Chukchi 2002, MMS 2008), the North Slope Foothills (State of Alaska 2006, 2007, 2008, 2009, 2010), Northwest NPR-A (USDOI BLM 2006, 2008), and Northeast NPR-A (USDOI BLM 2008, 2010, 2011).

Employment. As evidenced by Tables 3–36 and 3–39 in Chapter 3, Volume 1, without the discovery of oil at Prudhoe Bay in 1968, the number of jobs that would be available for North Slope residents would be substantially fewer than presently exist. Although most oil and gas-related jobs are held by people who reside outside of the North Slope Borough, jobs funded by the North Slope Borough's property tax revenues account for the majority of the jobs for North Slope Borough residents. The number of jobs in the oil and gas related sectors has fluctuated with the development of new fields. Current oil and gas extraction industry employment estimates prepared by the Alaska Department of Labor and Workforce Development indicate employment has grown from 5,500 jobs in January 2006 to 8,650 employed in the Northern Region (primarily North Slope Borough oil fields) in March 2011.

Per Capita Personal Income. As shown in Figure 3–9 in Chapter 3, Volume 1, real (inflation adjusted) per capita personal income in the North Slope Borough (by place of work) has increased recently when compared to gains in the Municipality of Anchorage, and the Fairbanks-North Star and Matanuska-Susitna Boroughs. After an extended period below $30,000, it has more than doubled since 2000 to nearly $67,000. This reflects increases in average North Slope oilfield wages to over $100,000, compared to average North Slope Borough government wages of less than $54,000 in 2010.

Summary of Past and Present Effects and their Accumulation

The North Slope Borough has transformed to a mixed cash-subsistence economy. Particularly in the last 40 years, residents have both benefited and grown accustomed to the result of modern capital development on the North Slope. In addition to the petroleum industry, the North Slope Borough has become a dominant economic organization on the North Slope. The North Slope Borough taxes the oil and gas facilities and uses the revenues to provide education and a wide array of other public services within its boundaries. Property taxes on oil and gas infrastructure provide over 82 percent of the total revenues received by the North Slope Borough in 2009.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

Continued recreational, research, and other activities are expected to largely follow historic economic patterns. Growth and development associated with villages and military sites are also expected to continue.

Oil and Gas Exploration and Development Activities

Events that would affect the economy of the North Slope Borough and the state of Alaska result from existing and future onshore and offshore oil and gas leasing and development, assisted by the potential construction of natural gas pipelines and a road to Umiat. Oil and gas exploration and development will occur on existing leases on

State and Native-owned lands east of NPR-A, Federal and Native-owned leases in NPR-A, and Federal and state leases in the Beaufort and Chukchi Seas. Future oil and gas lease sales with subsequent exploration and development may occur in the NPR-A, Chukchi Sea, Beaufort Sea, and lands east and west of NPR-A. Construction of a natural gas pipeline is required to take North Slope gas to market, so would be important to the local and state economy. Depending on the availability of natural gas from other resources, the North Slope gas could be important to the economy of the Midwestern states or other destinations outside Alaska. A foothills route from the Dalton Highway to the Colville River or into NPR-A at Umiat would improve the economic potential of oil and gas resources in that area, probably leading to earlier production schedules and possibly resulting development of some marginal accumulations.

The BLM, Bureau of Ocean Energy Management, and State of Alaska will continue to hold lease sales for onshore and offshore oil and gas exploration in Alaska. The participation of the oil and gas industry in recent lease sales demonstrates the oil industry's response to the high cost and geologic risk for accumulations in areas located far from current infrastructure. While some exploration activities are occurring at remote locations with potentially massive accumulations, most development is located near existing infrastructure in order to reduce production costs and maximize the use of existing infrastructure. As a result, fewer bids are received for tracts away from infrastructure, particularly within NPR-A.

Alpine West is proposed to be located within the NPR-A, on Kuukpik Native village corporation land surface and Arctic Slope Regional Corporation Native regional corporation subsurface oil and gas leases. The royalties to Arctic Slope Regional Corporation from production of these fields will generate revenues for the corporation and its shareholders. Seventy percent of these petroleum royalties will be shared with the other Alaska Native regional corporations in accordance with Section 7(i) of Alaska Native Claims Settlement Act.

Revenue. Alaska Department of Revenue's current estimates indicate annual petroleum revenue increasing to nearly $7.3 billion by 2020, an increase of $2.3 billion from 2010. Its proportion of general fund revenue will hold steady at about 90 percent through the period (Alaska Department of Revenue 2011). Potential oil production from known discoveries on existing leases throughout the North Slope is included in this forecast, but does not reverse the trend of declining oil production on Alaska's North Slope at a 6 percent rate. Alaska North Slope production, including offshore oil, is expected to decline from 644 thousand barrels of oil per day to 530 thousand barrels of oil per day, even with production from new development such as Alpine West and Greater Mooses Tooth. Minimum flow for the Trans-Alaska Pipeline System is approximately 350 thousand barrels of oil per day (Alyeska 2011).

If a gas pipeline is constructed to bring North Slope gas to market, revenues could increase substantially beginning in years after 2020, with new gas-related revenues offsetting revenue losses associated with the declining oil production trend. The Final Environmental Impact Statement: Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way (Trans-Alaska Pipeline System Renewal) in 2002 estimated that revenues from a gas pipeline would amount to $189 million annually in royalties and severance taxes on the gas produced and $188 million annually in property taxes on the pipeline infrastructure (USDOI BLM 2002). Prices, property and production tax calculations, and other considerations have changed to possibly make these estimates at the low end of the range. More recent projects have not estimated governmental revenues yet, as they continue to refine engineering and other estimates.

In addition to a property tax on new pipeline infrastructure, it is likely that additional infrastructure would be built on the North Slope to produce gas for market and, thereby further increase property tax, and possibly, other revenues.

Employment. Oilfield employment is based on equipment requirements, with the number of wells, miles of pipeline, and size of processing facilities having greater influence on workforce numbers than does production volume. This results in more employees per barrel of oil in later years of production than in early years, unless there are offsetting improvements in technology over time. However, in the government sector and other sectors funded primarily by the State's petroleum revenues or North Slope Borough's property tax receipts, employment is expected to decline as receipts decline over the long term.

If no gas pipeline is built but additional oil resources are developed onshore and offshore from current leases, employment in the oil and gas sector and the number of state and local government jobs supported by petroleum tax revenues could remain at or above recent levels for a number of years before declining. Development of a pipeline corridor across NPR-A could result from development of existing offshore leases. No project has been proposed, but construction of oil and gas pipelines would employ a large number of workers for a few years. When oil production declines below the Trans-Alaska Pipeline System minimum flow requirement, either a replacement line must be built to continue transporting oil from the North Slope, or all Alaska North Slope oil-related employment will cease when the infrastructure is removed and reclamation is complete.

New development from onshore and offshore discoveries made on future leases will maintain or increase oil volumes flowing in the Trans-Alaska Pipeline System from current levels, both maintaining levels of employment at current production sites and providing new employment opportunities. The Bureau of Ocean Energy Management estimates average annual direct, indirect, and induced employment in the Arctic region would be between 3,457 to 12,665 jobs lasting 40 to 50 years for leases expected to be issued under the proposed alternative in the Outer Continental Shelf Leasing Program for 2012 through 2017 (Bureau of Ocean Energy Management 2012). Employment estimates for development of state and Arctic Slope Regional Corporation minerals are not available, but recent leasing and subsequent actions have certainly had an impact in recent increases to industry employment (from 8,400 in 2005 to 12,200 in 2010 (Alaska Department of Labor and Workforce Development 2011)), and in Alaska's unemployment rate dropping below the national average since 2008.

Short-term employment on the North Slope, in Fairbanks and other parts of Alaska will increase substantially if a gas pipeline is built. The Trans-Alaska Pipeline System Renewal FEIS estimated up to 7,200 direct jobs per year during an 8- to 10-year period with an additional 3,300 indirect jobs statewide for a gas line project. In addition, long-term employment in both the oil and gas sector and government jobs supported by petroleum tax revenues would increase for about 30 to 40 years after construction of the pipeline. Again, the Trans-Alaska Pipeline System Renewal EIS estimated gas line operations would employ an average 550 workers, with an additional 1,250 indirect jobs. The current plans for the Alaska Pipeline Project indicate work will begin in 2016, and pipeline construction to require a peak workforce of 5,000 to 7,000, with thousands of additional personnel to construct compressor stations, meter stations, and the gas treatment plant facility. It is estimated that 850 workers would construct the gas treatment plant on the North Slope and about 1600 would construct the northern segment of the pipeline. Between 35 and 50 persons would be employed to operate the pipeline with an additional unspecified number in support, and a total of 500 for the gas treatment plant operation (Alaska Pipeline Project 2011). The Alaska Gasline Development Corporation project plan for Alaska Stand-alone Pipeline indicates peak construction labor will occur in the first summer at around 5,400 personnel with about 1,750 housed north of the Brooks Range divide, but does not have further estimates (Alaska Gasline Development Corporation 2011a and 2011b). Estimates for Alaska Pipeline Project and Alaska Stand-alone Pipeline do not identify local or Alaskan employment, but both indicate they will emphasize in-state and local employment as mitigation measures. Neither proposal has estimated indirect or induced employment, so the Trans-Alaska Pipeline System estimate of 3,300 indirect jobs for construction and 1,250 indirect jobs for operations suggests the magnitude of additional employment from the gas pipelines, for each project.

Employment information is not available for construction of the Foothills West Road from the Dalton Highway to the Colville River. Studies are still being prepared, but it is expected that there will be a significant number of direct, indirect, and induced jobs. Although additional oil and gas employment may result from the construction, its primary benefit would be in accelerating the development of the oil and gas resources.

The Bureau of Ocean Energy Management has estimated employment for cleanup of spills related to offshore development and production at 60 to 90 jobs for up to six months cleaning spills of over 1,000 barrels, but did not quantify employment for catastrophic discharge in its recent Draft Programmatic EIS (Bureau of Ocean Energy Management 2011b). While some workers would come from affiliated projects, additional workers might come from outside the North Slope Borough.

Based on the information above and estimates for data not otherwise available, the cumulative effects of activities outlined in section 4.8.3.2 are projected to generate an average of about 18,000 new direct and indirect jobs for oil and gas activities per year for up to 50 years, plus 60 to 90 jobs for six month if a small spill occurs. Over 20,000 new direct and indirect jobs would be created for 2 years or longer for pipeline construction, plus about 3,600 for pipeline and gas plant operations for thirty to forty years. An unknown number of jobs would be added for the Foothills West road construction.

For the 40 to 50 year life of oil and gas activities, direct and indirect employment is expected to average 18,000 employees, with 280 from the North Slope Borough and 4,800 to 12,510 from the rest of Alaska. For the two gas pipelines, peak construction direct and indirect employment is expected to reach 13,900 for a year or two, with up to

1,600 jobs potentially available to North Slope Borough residents, and the remainder from the rest of Alaska or outside Alaska. Pipeline operations are expected to total 3600 direct and indirect employment for 30 or more years, with over 100 from North Slope Borough and up to 2,450 from the rest of the U.S.

Per Capita Income. Per capita income in the North Slope Borough is expected to largely relate to the success of oil and gas activities in the Borough, particularly for employees of the Borough and its agencies. Future changes in other employment opportunities and migration of North Slope Borough residents would also affect this indicator. A longer-term trend in decreasing per capita income may occur unless North Slope Borough residents seek opportunities in the North Slope petroleum industry. The availability of employment opportunities in the NPR-A and nearby lands, with development and production of known and potential oil and gas fields, could increase employment opportunities, particularly for residents who live close to the fields. While wages associated with this employment could raise the per capita income for residents, it may represent a very small increment for the North Slope Borough when combined with the potential of increased subsistence travel costs. For the state of Alaska, changes in the planning area will have little effect on per capita income, which is expected to continue to grow.

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

Continued recreational, research, and other activities are expected to largely follow historic economic patterns. Growth and development associated with villages and military sites will increase the number of jobs and perhaps the per capita income in the North Slope Borough if the level of activity increases.

The property tax assessment in 2031 would include current infrastructure, additional onshore infrastructure for wells, processing facilities, infield pipelines, regional pipelines, and gas pipelines. The Foothills West road would not be subject to taxation. Although forecasts have not included these resources, the total excluding NPR-A may result in at least doubling of the current property tax receipts, to over $540 million for the North Slope Borough. Activities resulting from federal leasing identified in Alternative A would represent an additional $138 million annually for North Slope Borough, Alternative B-1 $90 million, Alternative B-2 $100 million, Alternative C $201 million, and Alternative D $221 million annually if all accumulations are developed concurrently. For Alternatives A, C, and D, the NPR-A contribution would be a major benefit to the North Slope Borough and Borough-related employment by nearly doubling the available budget. For Alternatives B-1 and B-2, the NPR-A activities would be a substantial benefit representing an addition of nearly 20 percent or more.

Federal and state royalties and taxes from the other activities have not been quantified. For the NPR-A resources as modeled, federal revenues would total $24 billion for Alternative A, $16.6 billion for Alternative B-1, $16 billion for Alternative B-2, $27 billion for Alternative C, and $29 billion for Alternative D. This would be a small benefit to the federal budget for all Alternatives. State revenues from NPR-A activities would total $24 billion in Alternative A, $16 billion in Alternative B-1, $15 billion in Alternative B-2 $23 billion in Alternative C, and over $25 billion in Alternative D. In Alternatives A, C, and D, this would add nearly $1 billion annually, or about 16 percent of revenues, which would be a substantial benefit. For Alternatives B-1 and B-2, the nearly $0.6 billion would be an addition of more than 8 percent for a moderate benefit.

Revenues and employment from offshore oil and gas development could be reduced by an unquantified amount under Alternatives B-1 and B-2 by increasing the cost of pipelines to transport products to market around the areas closed to non-subsistence infrastructure. Additionally, the more extensive area of infrastructure prohibitions along the Beaufort Sea found in Alternative B-1 could further discourage offshore development north of the NPR-A. To the extent that offshore development is reduced, the potential for development of resources in the northwest regions of the NPR-A may also be reduced. This is because proximity of operations creates a synergy in oil and gas areas, largely due to the ability to share pipelines and other facilities, and reduce costs for support activities and services. Conversely, extensive offshore development north and west of the NPR-A could result in improved economics for smaller oil and gas accumulations within the NPR-A that are near to pipelines and other facilities used for offshore production.

It is anticipated that North Slope Borough residents could be fully employed during activities identified in 4.8.3, at least during large pipeline construction, in both direct and indirect jobs. (Although the construction and exploration labor demands exceed current unemployment in the Borough, most jobs are 3 to 36 months, so an individual could fill multiple vacancies over the time of activities, and all will occur as large age cohorts enter or develop in the workforce.) Most relevant is the estimate of average annual long-term employment totaling 400 in an area with nearly 300 currently unemployed and more than 600 children reaching workforce age in the next 5 years. The activities in NPR-A are expected to employ an annual average of 577 in Alternative A, 357 in Alternative B-1, 386 in Alternative B-2, 636 in Alternative C, and nearly 700 in Alternative D. With commitments of training and appropriate skills and interests, this would allow current and future workers in North Slope Borough to be fully employed. Higher employment rates would be a substantial benefit to the residents of North Slope Borough.

Annual employment of Alaska residents (excluding residents of the North Slope Borough) would increase by about 12,300 jobs during the activities considered in the cumulative scenario. For activities in NPR-A, average direct, indirect, and induced employment in the rest of Alaska is estimated at 10,700 for Alternative A, 7,000 for Alternative B-1, 7,400 for Alternative B-2, 11,600 for Alternative C, and 12,300 for Alternative D. This would be a limited beneficial impact for Alaska. Additional jobs filled by residents from outside Alaska would be a negligible benefit to the rest of the U.S.

The potential proximity of NPR-A communities to development in and very near the Reserve can provide opportunities to those communities. These opportunities could extend to community businesses that might provide goods and services, as well as residents who might obtain work as a result of the development and production activities. Wainwright may similarly benefit from offshore activities in the Chukchi Sea. This could be a major benefit to those communities, particularly if participation in subsistence became more expensive as a result of nearby oil and gas activities.

Conclusion

Subsistence activities (non-cash economy) and the oil and gas industry (cash economy) are the primary factors that affect the economic livelihood of the North Slope residents. The North Slope Borough has successfully leveraged tax revenues generated from oil and gas properties to improve the quality of life of its residents by providing basic services such as water, sewer, electricity, fire protection, police protection, education, health services, and by building infrastructure to support these services through capital improvement projects. Construction jobs associated with the North Slope Borough's capital improvement projects have provided residents with employment opportunities that pay relatively well and allow for flexibility to accommodate subsistence activities. Alaska has benefited statewide from revenues resulting from oil production, including the Alaska Permanent Fund Dividend.

The development and production of resources within NPR-A or elsewhere on the North Slope or adjoining offshore could also have implications at the national level. The Department of Energy estimated that the contribution of North Slope crude to domestically produced oil supplies would decline from 18 percent in 2004 to 14 percent in 2020; this decline could be mitigated, but not offset, by North Slope and offshore oil production. Any increase in domestic oil production is expected to reduce U.S. dependency on foreign oil supplies, and, in turn, improve national energy security and the overall balance of trade.

For the long term, it is expected that before 2100, property tax revenues will decrease as North Slope oil and gas production decline and facility values depreciate. Correspondingly, historical employment data suggest a similar decline in the number of jobs and amount of per capita income in the North Slope as a result of declining Borough revenue.

A significant effect of climate change for the North Slope Borough could be changes in sea levels. Because villages are primarily located at or near sea level, any increase in mean sea level or violent storms may require relocation of part or all of villages and subsistence camps. This would have a major negative economic impact to the villages and the Borough, and a substantial impact to the state if it must help fund the relocation. It is estimated that the small village of Kivilina on the Chukchi Sea south of North Slope Borough would cost $400 million to relocate (D'Oro 2010). Both Barrow and Wainwright would be substantially more expensive given their size and extensive infrastructure.

4.8.7.21 Public Health

Past and Present Effects and Their Accumulation

Over the last 50 to 100 years the population living in the NPR-A area has experienced rapid modernization and acculturation, with significant changes in diet, housing, employment, and traditional culture. These changes have been accompanied by a shift in the burden of disease experienced by the population, as infectious disease and infant mortality have abated and chronic disease and cancer have become leading causes of death. This phenomenon, known as the epidemiologic transition, is typical in any population as it develops, but is accentuated in populations experiencing rapid modernization. Indigenous populations worldwide have seen dramatic health changes over the last century as modernization has brought with it significant changes in diet, sociocultural systems and economic conditions (Trovato 2001).

Much of the change associated with this transition has been for the better. For example, life expectancy has increased, while infant mortality and age-specific mortality have decreased. Rates of infectious diseases—including tuberculosis and vaccine-preventable illnesses—have also declined. Health care services, public health programs and municipal health infrastructure such as sanitation and water treatment have also improved with development.

However, the epidemiologic transition also comes with adverse health outcomes. The rates of chronic diseases such as cancer, cardiovascular disease and metabolic disorders tend to rise. Health outcomes related to social conflict and stress also increase. Among populations living in the NPR-A, as with most other circumpolar and indigenous populations, development has been commensurate with increases in alcohol and substance misuse, suicide, violence and other social dysfunction.

Much of the change in the burden of disease among the Iñupiat is a result of general development, economic growth and cultural change. The extent to which oil and gas development has contributed to it is uncertain; however, there are well-documented causal pathways between resource development activities and changes in both health determinants and health outcomes. Local testimony supports the association of oil and gas with both positive and adverse health outcomes.

Some of the specific health concerns that have been brought up with previous North Slope development—particularly but not limited to oil and gas development—include:

- Air contamination effects on human health. Residents have expressed concern about air quality and effects on public health, including increases in pulmonary disorders such as asthma, certain types of cancer, and thyroid disease (National Research Council 2003).
- Contaminated sites. As of November 2011, the Alaska Department of Environmental Conservation listed over 150 unremediated contaminated sites in the North Slope Borough, and a further 44 in the Northwest Arctic Borough. The extent and nature of contamination on those sites varies considerably (National Research Council 2003). Not all are attributable to oil and gas activities, but all are related to past development in the area. North Slope residents have repeatedly voiced concern and reported stress over potential contamination, especially as it relates to traditional foods.
- Interference with subsistence activities. Interference with subsistence activities is described in section 4.8.7.13 and may be associated with changes in dietary patterns and nutritional outcomes.
- Aesthetic, cultural and spiritual effects. As described in the National Academies of Sciences 2003 report on cumulative effects of oil and gas activities in the North Slope, "Many activities associated with oil development have changed the North Slope landscape in ways that have had accumulating aesthetic, cultural, and spiritual consequences… Those consequences have increased in proportion to the area affected by development, and they will persist as long as the landscape remains altered."

- Improved services. Improved services have also been enabled by development, including "community facilities, schools, modern water and sewer systems, village clinics, child emergency shelters, behavioral outpatient and residential programs that provide mental health care and counseling for substance abuse and domestic violence... quality and quantity of health care for elders, especially for those who need assisted-living services.... and low-cost natural gas heating for their homes" (National Research Council 2003).

The inextricable connection between positive and negative health effects on the local population has described well by George Ahmaogak, a former North Slope Borough Mayor:

> The benefits of oil development are clear — I don't deny that for a moment. The negative impacts are more subtle. They're also more widespread and more costly than most people realize. We know the human impacts of development are significant and long-term. So far, we've been left to deal with them on our own. They show up in our health statistics, alcohol treatment programs, emergency service needs, police responses –you name it (Ahmaogak 2004).

Although the exact contribution of oil and gas development to the ongoing transition in the health of the people of northern Alaska is unknown, its role as the primary driver of economic and industrial development in the region does support at least an indirect causal association.

Future Effects and Their Accumulation

Activities Not Associated with Oil and Gas Exploration and Development

As described in sections 4.8.2 and 4.8.3, there are a significant number of activities planned and/or approved in the planning area, including oil and gas exploration, development and production; scientific research activities; mining projects; military developments and activities; transportation plans; community development projects; and recreation and tourism activities. These future actions will continue to influence public health and safety. The common components of these future actions that are most likely to drive public health and safety outcomes are:

- A potential growth in population in the communities in and near the NPR-A
- In-migration of workers, visitors, or temporary residents not originally from the area
- Economic changes at the level of both individual residents and the Native Corporations
- Changes in the level or success of subsistence activities
- Changes in/improvements to public infrastructure
- Potential exposure to environmental contaminants
- Changes in access to or use of the land
- Continued acculturation of the Iñupiat people and alteration of sociocultural traditions

As the reasonably foreseeable future actions continue the path and progress of development seen in the past, it can be expected that the changes in public health and safety outcomes will follow the same trends that have been observed in recent years. These trends include:

- Improvements in general health indicators such as mortality and life expectancy
- A shift in the burden of illness away from infectious disease and towards higher rates of chronic conditions
- Changes in diet towards increased use of store-bought foods with associated changes in nutritional outcomes
- Increasing disparities in health outcomes between the more-wealthy and the less-wealthy
- Continuing high rates of social ills including crime, violence, and alcohol and drug misuse

Oil and Gas Exploration and Development Activities

The health transition in the population of Northern Alaska over the last several decades is the result of general economic development and social change and is not directly the result of oil and gas exploration and development activities. Nevertheless, the pattern of development and modernization that has taken place in the in and near NPR-A combined with the area's unique culture and geography has led to the creation of certain health areas that are of particular importance. These health concerns represent areas of vulnerability whereby further oil and gas-related development may have a disproportionate impact on health and safety. These areas include:

- **Injury and trauma.** The population living in the NPR-A area experience high levels of injury and trauma, with high morbidity and mortality rates across most age groups. While this is common in any rural or remote region, it is particularly high in populations that engage in subsistence activities. The high rates of injury in the North Slope Borough may be exacerbated by the way in which traditional subsistence activities have adapted to the presence of development - for example, hunters report that they need to travel farther to reach subsistence resources due to both a displacement of animals and to avoidance of industrialized areas.
- **Social pathologies such as alcohol and drug misuse, social dysfunction and violence.** Oil and gas development, with its large in-migrations of outside workers and influxes of money into the local economies, is associated with increased social pathology. In addition, the development of roads and seasonal access to the region increase opportunities to import alcohol.
- **Health disparities.** There already exist patterns of economic and health disparity in communities in and near NPR-A, with health outcomes and health determinants unevenly distributed within and across the population. Recent development, as well as future development has the potential to exacerbate these disparities both because of the uneven distribution of the "rewards" of development and because of uneven distribution of the risks.

New development tying into existing infrastructure to the east of the NPR-A will exacerbate some of these impacts. In particular, a road to Umiat could introduce the potential for competition and conflicts between outsiders and hunters from Anaktuvuk Pass, and may lead to less successful harvests and greater stress for members of that community. A road will also introduce a new potential route for smuggling of alcohol and drugs to Anaktuvuk Pass and to other communities via the Colville River. Similarly, the potential extension of seasonal or permanent roads into the northeast of the NPR-A might compound issues of conflict and smuggling in Nuiqsut and other North Slope Borough communities.

Of particular significance for public health and safety is the potential for further increases in offshore oil and gas exploration, development and production following the demonstration of economically feasible opportunities in the Chukchi and Beaufort seas. According to key informants within the North Slope Borough, a large-scale development of the oil and gas industry offshore would be new and would bring with it unfamiliar health risks (George 2011, pers. comm.; Camilleri 2011, pers. comm.). In particular, a ramp-up of offshore development is expected to lead to potentially substantive changes in public health outcomes via three pathways: a) the displacement of marine mammals and the subsequent reduction of success and safety of subsistence hunting; b) the potential for contamination and the fear of contamination through oil spills or routine discharge; and c) substantially increased economic returns to the North Slope Borough, village corporations and individuals with resulting positive and negative health effects and disparities. In addition, increased employment associated with the staging of offshore activity and the construction of onshore facilities and pipelines will be associated with potential negative impacts of work camps on proximal communities, as discussed in section 4.3.21.2 (Volume 2).

Contribution of the NPR-A IAP/EIS Alternatives to Cumulative Effects

The activities specified under the Alternatives of the NPR-A IAP/EIS will have broadly similar contributions to the cumulative effects on public health in the region, and the pathways through which health effects in the study area are those that are described in section 4.3.21.2 (Volume 2). The key differences among the alternatives that will affect their overall contribution to cumulative effects on public health are related to the extent and speed of development and the degree to which protection of traditional livelihoods will help buffer potential negative consequences.

Diet and Nutrition. The Inupiat, like many other northern indigenous populations, have been undergoing a slow transition from a traditional diet to a diet more heavily focused on less nutritious and often more expensive store-bought foods. This dietary shift has been implicated in rising rates of obesity, diabetes and cardiovascular disease and may play a role in the high rates of food insecurity in the region. The shift is occurring regardless of oil and gas development; however, development can compound the shift by interfering with the success of subsistence activities, undermining confidence in the healthiness of harvested food, and providing money and access to store-bought foods. In some cases, oil and gas development can support a subsistence diet by way of improving access to resources or providing the financial means to procure gas, ammunition, and other material necessities to hunt. All alternatives will contribute to the transition in diet insofar as they interfere with the success of subsistence activities or, conversely, help protect and promote a traditional diet. Alternatives B-1, and to a lesser extent B-2, are likely to help temper the potential negative impacts of oil and gas development by providing large tracts of land where there will be little conflict between users, thus minimizing perceptions of contamination, dispersion of animals and voluntary avoidance of areas by hunters. The activities under Alternative A are likely to contribute to cumulative changes in diet and nutrition and will be associated with the continued slow transition away from traditional food in the region. Alternative C could be expected to have a larger impact on diet if the success of the caribou hunt in the area is adversely affected. Alternative D, which carries the potential for the most widespread industrial activity and resulting impacts on animal stocks and conflicts between subsistence users and industry, could result in a significant acceleration of the transition away from a traditional diet and subsequent increases in the rates of diabetes, obesity, cardiovascular disease, and other metabolic outcomes.

Under all alternatives, impacts on diet and nutrition will be compounded by any effect that climate change and offshore development have on reducing the success of marine mammal harvests. If marine harvests are adversely affected, on-shore subsistence resources will be significantly more important for the Inupiat to maintain traditional diets and food-sharing systems.

Environmental Exposures. Current levels of contamination of traditional food and water supplies in the region are low and, in the absence of major spills or accidents, are unlikely to significantly change under any alternative. Perception of contamination, on the other hand, is already high. Extensive development, particularly in areas of traditional use and subsistence harvest as would be the case under Alternative D, will increase the perception of contamination and may result in changes in consumption patterns and stress.

Air and water quality across the region are currently good. Local impacts due to site-specific activity are possible, but will depend on the characteristics of individual site plans and the presence of exposed villages or camps. The analyses of air and water quality elsewhere in this chapter provide an extensive discussion of anticipated changes in air and water quality with respect to human exposure (see Section 4.3.1 “Air Quality and Climate” in Volume 2). More widespread development will result in a greater number of individuals on the land or in camps being exposed to local air, and possibly water, exposures as well as noise from fixed sites and aircraft. In communities, economic activity, growth, and vehicle use will continue to be primary drivers of air and noise pollution. Under each alternative, all will increase gradually in the region.

Infectious Disease. The transition towards chronic disease and away from infectious disease as a leading cause of illness in the region will continue under all alternatives. Nevertheless, a migratory workforce and work camp environment carry risks of sexually transmitted and other infections spreading from the outside workers into the community. The volume of workers and degree of intermingling between migratory workers and local residents are both associated with a higher risk of infectious disease. All alternatives will continue to contribute to the relatively high rate of sexually transmitted infections in the region.

Safety. Rates of injury and trauma in the region are very high, as is common in young populations and cultures reliant on subsistence activity. Dispersion of animals and conflicts between users of land can lead to an increased risk of injury in hunters, compounding the risk of unpredictable weather and ice conditions that many Inupiat is associated with climate change. All alternatives will increase the likelihood of injury to a small degree due to the industrial use of land previously used only for subsistence activity. Alternative D has the potential to significantly increase land conflicts between subsistence users and oil and gas activity and subsequent injuries.

Acculturative Stress. The acculturation of the Iñupiat to a more westernized style of life—with decreased dependence on traditional foods, erosion of sociocultural support systems and decreased time put into subsistence activities—is ongoing and is associated with many health outcomes. These changes are similar to what has been experienced in other aboriginal populations in Alaska and worldwide. As such, oil and gas development in the area is only partially responsible for acculturation and exerts both positive and negative impacts on subsistence activity. The primary difference in the contribution of the alternatives under consideration to the cumulative impact of acculturation will be related to how well they preserve the opportunity to engage in meaningful cultural and subsistence activity. Alternatives B-1 and B-2, which have large sections of intensively used traditional land unavailable for leasing, are likely to help protect against overall trends of acculturation in the region. Alternative D has the potential to lead to widespread industrialization of the landscape that could restrict traditional activities and lead to conflicts between users, thus becoming a primary contributor to acculturation in the Iñupiat.

The harvesting of marine mammals in general, and of Bowhead whales in particular, is central to Iñupiat cultural and food systems. As such it plays a key role in maintaining and promoting public health in the region. Offshore oil and gas development in the Beaufort and Chukchi Seas may affect these systems, compounding the impacts of acculturation, climate change and onshore development in the NPR-A. The alternatives under consideration in this plan all tie in similarly to offshore development and include the potential for staging facilities for Chukchi exploration in the west of the NPR-A and a corridor for a pipeline across the NPR-A. Alternative B-1 does not allow for on-shore development in the NPR-A of a Beaufort Sea pipeline. If this in turn restricts development of Beaufort resources, then the potential impacts on harvesting in the Beaufort Sea will be reduced. However, a seabed pipeline to tie-in to existing infrastructure east of the NPR-A may occur under Alternative B-1, resulting in as great or greater impacts on marine ecosystems and subsistence activities and subsequent acculturative stress.

Economic Impacts and Health Care Services. Continuing economic development and revenues to the local governments under all alternatives will support maintenance of the infrastructure and systems required to protect these trends. The variation in year-to-year economic returns between alternatives will have only a marginal impact on health outcomes. However, the timing of the major impact that will result from the eventual decline in production and revenue, with subsequent health impacts by way of unemployment and restrictions in government services, is likely to be affected by the amount of land available for leasing.

The direct and indirect employment resulting from oil and gas exploration and development combined with the government and Native corporation revenues are all major contributors to the positive health changes in the North Slope Borough over the last few decades. The activities under all alternatives will provide substantially to these ongoing benefits, with greater levels of employment generally being more likely to be associated with good health. There is, however, potential for harmful health consequences of oil and gas development with regard to social pathology and health disparity are directly related to the rate and extent of development. Although development is driven largely by economic factors external to leasing plans, the amount and location of land available may lead to a greater contribution to cumulative ill effects on health under certain conditions. In the event of a sustained boom in oil and gas development it is possible that Alternative D will lead to less restrained growth and contribute substantially more to social pathologies and health disparity in the region.

Conclusion

The health of the Iñupiat has been in flux over the last several decades as the society has transformed and developed. While much of this change has been for the better and can be indirectly tied to economic development, infrastructure and employment, the strains on traditional systems has resulted in many negative health impacts. High rates of trauma, social dysfunction, and respiratory disease offset many of the gains that have been seen in maternal and child health and infectious disease. This pattern is typical of far northern aboriginal populations and is compounded in the region by the presence of the oil and gas industry.

While economic development is crucial to maintain and promote the positive impacts, protection and preservation of traditional systems—including meaningful connections with the land, subsistence hunting and food sharing, and social networks—has a primary protective role against many of the ill-effects associated with the change. To date, despite intensive industrialization of a portion of the North Slope, the Inupiat way of life has remained strong. A reliance on as-yet minimally impacted marine mammals, little interaction between Iñupiat communities and outside workers and preservation of on-shore subsistence activity despite oil and gas exploration and development have all helped mitigate many of the harmful health effects that have been seen in aboriginal populations elsewhere.

As development continues, the cumulative impact on these systems may erode their protective effects. Uncertainty over the impact of climate change on subsistence resources and related traditional lifestyles and culture (see section 4.3.21.2, Volume 2, for the discussion or relationships between subsistence and health outcomes) combined with new conflicts in use of the Chukchi and Beaufort Seas is a cause of concern among Iñupiat hunters and community members. Climate change may also result in increased injury and trauma, as unusual or unpredictable weather, water, snow and ice conditions make travel more hazardous (Brubaker 2011) and people may travel greater distances to find marine or land mammals or edible plants. Westward extension of oil and gas activity may lead to more conflict and less successful or desirable use of traditional lands. Meanwhile, infrastructure associated with development, including roads, pipelines and new work camps, has the potential to more effectively import some of the negative social impacts associated with industrialization.

Mitigations to enhance the positive impacts of employment and economic growth and reduce their negative impacts, while supporting traditional systems and subsistence activity, will enable continued improvement of population health in the region as development continues.

Section 4.9:

Unavoidable Adverse Effects

4.9 Unavoidable Adverse Effects

This section summarizes the unavoidable adverse environmental effects that would occur under the alternatives considered in this plan. Unavoidable adverse effects would be expected to occur during oil and gas exploration, development, and production operations. Many of the adverse effects identified in this section would occur only if a large or very large oil spill were to occur.

4.9.1 Air Quality

An increase in emissions of air pollutants would occur as a result of all alternatives. In all the alternatives and the cumulative case, the projected direct and indirect emissions would be less than emissions that have occurred due to North Slope oil and gas activities in the past when production rates were much higher. Although oil production will probably remain lower than peak production, gas production is expected to increase as it becomes produced commercially. BLM actions will comply with all applicable Federal, state, local, and Tribal air quality laws and regulations.

4.9.2 Paleontological Resources

Although paleontological resources are nonrenewable, invertebrate, marine and terrestrial plant fossils are so common as to be ubiquitous throughout the planning area and petroleum exploration and development activities are not considered to be a significant threat to that portion of the resource. Because of their relative rarity, the loss of vertebrate paleontological resources is potentially adverse, especially if it results in the loss of scientifically important fossils. Because the exact locations of unknown paleontological resources sites are generally unpredictable, their disturbance cannot be entirely avoided. However, surveys and inventories in areas of proposed oil and gas exploration and development activities which could potentially cause impacts to the surface/near surface are required before work is initiated. Thus, avoidance of vertebrate paleontological locales or other mitigation will occur and the incidence of potential impact should be greatly reduced. Lease stipulations and required operating procedures/best management practices that restrict or prohibit oil and gas drilling and development in streams and rivers will also reduce the potential impacts to vertebrate paleontological resources in the Reserve. Additionally, federal regulations and lease stipulations prohibiting the unauthorized collection of vertebrate fossils will also limit adverse impacts to the resource. Included in the required operating procedures/best management practices are mandatory awareness training programs for oilfield workers regarding the importance of preserving and not collecting vertebrate paleontological resources.

4.9.3 Soil Resources

While impacts to soils from exploratory drilling would occur over a small area, relative to the overall planning area and Arctic Coastal Plain, these impacts would be unavoidable and permanent. Development activities, such as the construction of permanent gravel roads and pads, could cause damage or loss of soil over the area affected. Construction of any oil and gas pipelines or the use of a gravel mine site would also permanently disturb or destroy soil in the immediate vicinity of the project. If a crude or refined oil spill occurred, the resultant impact to soils could extend beyond the immediate work area. However, lease stipulations and required operating procedures/best management practices would reduce the majority of effects. Some soil would be restored as sites are abandoned and reclaimed. Removal of gravel pads and roads may damage soils and leave remaining areas vulnerable to thermokarst since the insulating vegetation has been removed. However, due to the harsh Arctic climate, it could take several hundred years for soil productivity to reach pre-disturbance levels on abandoned pads and roads.

4.9.4 Water Resources

Unavoidable adverse effects on water quality could occur from spills into freshwater or estuarine water bodies. A very large crude-oil spill could have serious impacts to streams and lakes. While the petroleum residue from a spill could be flushed from most streams within a few years, the impacts to lakes and ponds could persist for decades. Additionally, a very large spill could saturate the tundra mat with oil, limiting the amount of crude oil that was recovered, and considerably lengthening the time over which impacts could occur. A spill that occurred in the winter could have similar impacts, although the snow and cold temperatures would retard the crude-oil runoff into the watershed as the snow soaked up the oil and limit the contamination. A spill that occurred during spring breakup or fall freeze-up could have the greatest impacts, since it would be extremely difficult, if not impossible, to contain the spill when ice was either breaking apart or forming into semi-solid slush pans or jumble ice. Spill cleanup in the watershed would involve containing the spill, diverting or isolating it within the waterbody, skimming off the oil, and treating the remaining oil-contaminated water and sediments. Prevention and rapid response with adequate removal equipment would minimize effects.

4.9.5 Vegetation

All of the direct and indirect impacts to vegetation described for all alternatives would be unavoidable. Seismic activities, overland moves, and exploratory drilling would occur during the winter when the ground is frozen and snow-covered. Such activities could cause impacts that linger from one year to decades, in the form of vegetation that appears greener than surrounding areas, shallow water tracks, ponding, scuffed or crushed tussocks, and ruts through tussocks. Impacts caused by oil or gas field development, such as burial of vegetation under gravel fill and contamination by oil spills, would be unavoidable, direct, adverse effects. Placement of gravel drilling pads, roads, airstrips, staging areas, and docks, as well as construction of oil and gas pipelines and the use of gravel mine sites, would permanently disturb or destroy soil and vegetation. These actions would account for about one-fourth of the total acreage of impacts to vegetation. Additionally, vegetation and soils may be altered or disturbed by the formation of impoundments where gravel structures alter drainage patterns, or by snowdrift or dust accumulation along gravel pads and roads.

Changes in plant community composition caused by these indirect effects of gravel placement would account for the other three-fourths of the area impacted by oil and gas field development. Impacts from moisture regime changes would have an adverse effect on the original plant community and its associated fauna, but perhaps a beneficial effect on the plant communities that colonize those areas.

4.9.6 Wetlands and Floodplains

All of the direct impacts to wetlands and floodplains described for all alternatives would be unavoidable. Seismic activities, overland moves, and exploratory drilling would occur during the winter and could cause impacts that linger from one year to decades, in the form of vegetation that appears greener than surrounding areas, shallow water tracks, ponding, and crushed and rutted tussocks. Impacts caused by oil or gas field development, such as burial of wetlands under gravel fill and contamination by oil spills, would be unavoidable, direct, adverse effects. Placement of gravel drilling pads, roads, airstrips, staging areas, and docks, as well as construction of oil and gas pipelines and the use of gravel mine sites, would permanently disturb or destroy wetlands, alter natural drainage systems and create impoundments. Changes in plant community composition resulting from dust and snowdrift accumulation could last long after the life of the development. The restoration of the natural drainage could take years after an oil or gas field was abandoned, equipment removed, and the roads and pads rehabilitated. Gravel mine sites within floodplains would create permanent water bodies, which could provide fish habitat if connected to streams.

4.9.7 Fish

Some effects on fish from oil and gas activities would be unavoidable despite protective management measures. This would include avoidance behavior from seismic acoustic energy and from concentrated vessel traffic in the vicinity of coastal ports; impeded migrations along the coast from causeways, unless a structural alternative is engineered to provide effective passage; sublethal effects from point and non-point source pollution, including oil spills; increased sedimentation, turbidity, and altered geomorphology due to floodplain gravel mining; and injury or mortality related to a small number of water use intakes. The consequences of these effects are discussed in section 4.3.7.2 (Volume 2).

4.9.8 Birds

Some effects on birds from oil and gas activities would be unavoidable despite protective management measures. This would include direct and indirect loss of habitat and behavioral alternation due to avoidance of developed infrastructure, vehicle traffic, human activity, and vessel traffic in the vicinity of coastal ports. Other effects would come from spills of hazardous materials, including oil spills, and mortality from collisions with human infrastructure or vessels. The consequences of these effects are expected to last for the life of the oil and gas development and perhaps longer.

4.9.9 Terrestrial Mammals

Some disturbance and disruption of caribou and some habitat alterations from oil development under all alternatives are unavoidable. Displacement or reduced habitat use by the Teshekpuk Caribou Herd, Western Arctic Herd, and Central Arctic Herd caribou are likely to be local (within 2 to 2½ miles of oil field roads and pipeline corridors) and long term (greater than 1 generation), and could persist over the life of the oil fields. For the Teshekpuk Caribou Herd or Western Arctic Herd, this could result in a shift of the concentrated calving area, if development occurred within that area. Some noise and disturbance of other terrestrial mammals would be unavoidable, but would be short-term and localized and would not substantially affect mammal populations. Any impacts to individual mammals due to direct contact by spilled oil would be unavoidable, direct, adverse effects. Any such impacts to mammal habitat due to spills would be unavoidable, indirect, adverse effects.

4.9.10 Marine Mammals

Seismic surveying, air, vessel, and ice road traffic, and construction activities would unavoidably disturb small numbers of seals but this effect would be very brief and would not impact population abundance or overall distribution in the Planning Area if appropriate den-sight surveys are conducted. Increased barge traffic associated with development will likely displace some migrating whales and possibly other marine mammals depending upon the timing and location of vessel traffic. However, such impacts could be mitigated by limiting vessel traffic during migration periods. The extent of effects of constructing a coastal docking facility to offload supply barges adjacent to the planning area would depend on its location, size, design characteristics, and whether the facility required an offshore access causeway.

4.9.11 Special Status Species

4.9.11.1 Special Status Species of Plants

Many of the direct impacts to vegetation described for all alternatives would be avoidable for sensitive species, because their growth sites could be avoided during development. Seismic activities and overland moves may not be able to avoid traveling over populations of sensitive species, but would occur during the winter when the ground is frozen and snow-covered. Such activities could cause short-term impacts for the most part, but still have the potential to unknowingly overrun some individuals causing plant death.

4.9.11.2 Special Status Species of Birds

Some effects on special status species (particularly spectacled and Steller's eiders and yellow-billed loons) from oil and gas activities would be unavoidable despite protective management measures. This would include direct and indirect loss of habitat and behavioral alternation due to avoidance of developed infrastructure, vehicle traffic, human activity, and vessel traffic in the vicinity of coastal ports. Other effects would come from spills of hazardous materials, including oil spills and mortality from collisions with human infrastructure or vessels. The consequences of these effects are expected to last for the life of the oil and gas development and perhaps longer.

4.9.11.3 Special Status Species of Terrestrial Mammals

There is likely very little land area within the NPR-A used by either the Alaska hare or the Alaska tiny shrew, if these species exist at all within the Reserve, so it is unlikely that either would suffer an adverse effect of oil or gas development. Moreover, surveys of a potential area of development (i.e., construction of permanent infrastructure) prior to permitting should determine the presence or absence of either species, and if presence were indicated development would likely be planned in a way to avoid impacts. Despite these efforts, it is possible for surveys to result in a false determination of absence when dealing with such a rare species. If development were to occur in such an area, there may be adverse effects that could be considered unavoidable.

4.9.11.4 Special Status Species of Marine Mammals

Impacts to special status whales and seals would be similar to impacts to marine mammals as described in section 4.9.10. For "pioneering" special status species such as humpback whales, impacts to individuals could have a larger detrimental effect on very local feeding populations (Hashegaen et al. 2009).

Activities with the most potential to affect polar bears include oil and gas exploration and development, aircraft and watercraft traffic, winter overland travel, and recreational and research activities. Lease stipulations, required operating procedures, and endangered species consultations with the U.S. Fish and Wildlife Service would effectively mitigate many of the potential effects to polar bears from oil and gas activities. For example, disturbance from seismic surveys could result in the displacement of maternal polar bears and their dependent cubs, abandonment of the den, and possible death of polar bear cubs. However, cross-country use of heavy equipment and seismic activities would be prohibited within 1 mile of known polar bear dens, and operators would be required to consult with the U.S. Fish and Wildlife Service before initiating activities in coastal habitat during denning season. If impacts to individual female polar bears and cubs were to occur in the unlikely instance that a den would go undetected during a survey, it would be considered an unavoidable impact because the operator would have taken the appropriate precautions to avoid such disturbance. Endangered species consultations will also be used to address potential impacts associated with permitted, non-oil and gas activities. Some disturbance to polar bears by routine activities within the NPR-A is considered unavoidable. Severity of the disturbance may depend on whether an individual bear is denning or non-denning. Severity could range from a one-time event that might disturb an individual bear only during the duration of the event (e.g., passage of a vehicle) to a level of disturbance that results in mortality of individual bears (e.g., through defense of life kills or through activities that disturb denning bears, resulting in den abandonment and death of cubs).

Actions considered for the planning area within this IAP/EIS have the potential to affect Pacific walrus if they take place in NPR-A's coastal waters. Walrus are most vulnerable to disturbance where they are aggregated at haulout areas, and they are particularly vulnerable at haulouts on land. Activities that create noise or visual disturbance around haulouts have the most potential to affect Pacific walrus. These activities include aircraft, watercraft, and foot traffic and activities in support of oil and gas exploration and development. Lease stipulations, required operating procedures, and best management practices would effectively mitigate many of the potential effects to walrus from oil and gas and other permitted activities.

For example, minimum altitude and distance requirements for aircraft and watercraft in the vicinity of walrus on terrestrial or ice haulouts should minimize the potential for disturbance to walrus by creating visual and noise buffers. However, given the sensitivity of walrus to disturbance, some impacts to walrus as a result of human activity within the NPR-A will be unavoidable. Severity of impacts from a disturbance event could range from a one-time event that might disturb or displace a single walrus only for the duration of the event (e.g., passage of watercraft) to a level of disturbance that results in a stampede event, causing mortality of one or many individuals (e.g., through trampling or separation of cows and calves). Severity of a disturbance event may depend on many factors, including sex, life stage, whether the walrus is found in an aggregation or singly, and activity and location of the walrus at the time of the disturbance. Females, particularly with dependent calves, may be the most intolerant of disturbance (individuals tend to be more tolerant of disturbance than groups) and walrus in the water may be more tolerant of disturbance. Walrus hauled out on ice show variable reactions, and walrus hauled out on land consistently flee the source of disturbance.

4.9.12 Cultural Resources

Cultural resources are nonrenewable and while numerous, are not ubiquitous across the NPR-A. Any adverse effect to the resource is generally considered negative. Because the exact locations of unknown cultural resources sites are somewhat unpredictable, their disturbance cannot be entirely avoided. Cultural resources within the NPR-A relate to the entire span of human occupation of the region, including locales relating to the first humans to enter the Western Hemisphere. Historic and prehistoric sites may be located anywhere within the planning area and represent varied ages, cultures, and functions. Because soil forms slowly in the Arctic, sites that are thousands of years old may be located near or on the surface. Surveys and inventories for cultural resources in areas proposed for oil and gas exploration and development are required to be conducted before any potentially surface disturbing activities can begin. Therefore, the potential for adverse effects to the resource should be drastically reduced. The timely intervention following the discovery of cultural resources that potentially could be impacted will effectively mitigate many effects, either through site avoidance or data recovery. Excavation to recover remaining site data from an inadvertently disturbed site could result in the total destruction of the site, although the recovered data would, in most cases, effectively mitigate the destruction.

4.9.13 Subsistence

Bowhead whales, beluga whales, caribou, fish, seals, birds, wolves, and wolverines are important subsistence resources for North Slope Borough residents. Noise and disturbance from seismic surveys, exploration, development, and production could affect the harvest of subsistence resources for the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Wainwright, and Point Lay. Additionally, disturbance could cause potential short-term impacts to long-tailed ducks and some eider populations. No harvest areas would become unavailable for use, but many subsistence users would avoid areas of oil development because of regulatory exclusion (real or perceived), and potential for contamination of species.

While noise, traffic disturbance, and oil spills would produce chronic, short-term impacts on subsistence species, none of these impacts would lead to the elimination of any subsistence resource. Disturbance to, and displacement of, caribou could lead to an unavoidable reduction in the total annual caribou harvest by making the harvest more difficult, costly, and time consuming for subsistence hunters. Wolf and wolverine harvests would be reduced in areas of human activity, while bear and fox could habituate to oil and gas activities within the NPR-A. Effects on the harvest of other species from noise and traffic disturbance, and construction activities should be avoidable, if mitigated. If oil and gas infrastructure were located in subsistence hunting areas, some (real or perceived) restrictions on access by subsistence hunters would be unavoidable.

4.9.14 Sociocultural Systems

The inability to harvest sufficient quantities of bowhead whales as a result of disturbance could cause unavoidable effects on Iñupiaq traditional harvesting and sharing practices. These effects would increase if the harvest shortage lasted more than one whaling season. Disturbance effects on caribou could disrupt sociocultural systems for an entire season or more; nevertheless, it is not expected that these disruptions would displace ongoing sociocultural institutions, community activities, or traditional practices for harvesting, sharing, and processing resources. Some cultural values, such as sharing, could be reinforced by shortages in the short term, but could be strained after several seasons of harvest shortages. Long-term harvest failures or the loss of a resource would irreparably strain the bonds of sharing and reciprocity that bind Iñupiaq communities. The loss of the resources that Iñupiaq people use to define themselves would further distance younger generations from their Iñupiaq heritage and could cause profound changes in the community. Federal, North Slope Borough, and community-supported social programs with adequate funding would mitigate many of the sociocultural consequences of oil and gas development in the NPR-A. However, unavoidable repercussions to the communal practice of sharing of subsistence resources could occur.

4.9.15 Environmental Justice

The Environmental Justice Executive Order requires the consideration of the potential effects of proposed projects on Alaska Native subsistence activities. Noise and disturbance from routine development activities would be unavoidable. The most substantial unavoidable environmental justice effects on Alaska Native communities would be from exploration and development activities that reduced the populations or production of terrestrial mammals, water birds, and fish or subsistence users' access to these resources. These effects would primarily affect subsistence resources and would thus fall disproportionately on Alaska Native minority populations. Most other subsistence effects would be short term, local, and relatively minor, and would not be expected to raise environmental justice issues.

4.9.16 Recreation Resources

Some adverse effects to recreation from oil exploration and development are unavoidable. These effects would be a direct result of exploration and development activities and facilities such as the winter activities of seismic, ice roads/snow trails, ice pads, ice airstrips, and nonseasonal activities such as drill pads, pipelines, and gravel roads. The winter activities effects would be short-term, while the nonseasonal activities effects would be long-term. Activities could displace recreationists or introduce noise and signs of man's presence (e.g., aircraft overflights), thus adversely affecting their experiences on the public lands. However, the degree of the effect would depend on the actual location of the activities and their relationship to recreation opportunities.

4.9.17 Wild and Scenic Rivers

Some effects on wild and scenic river values from oil and gas activities would be unavoidable despite protective management measures. Aircraft overflights of eligible rivers might increase from oil and gas activities, and if this happens, there would be some impact to recreation and subsistence. Recreation experiences would be less primitive, and subsistence hunts could be disrupted by such overflights.

4.9.18 Wilderness Characteristics

Some adverse effects to scenic quality, solitude, naturalness, and primitive/unconfined recreation from oil and gas exploration and development are unavoidable. These effects would be a direct result of exploration and development activities and facilities such as seismic, ice roads/snow trails, ice pads, ice airstrips, drill pads, pipelines, and gravel roads. The effect would be limited to the viewshed and/or noiseshed of the activities, leaving most of the planning area unaffected. If it is determined in the future that these activities impair wilderness characteristics the areas would be excluded from the Lands with Wilderness Characteristics Inventory.

4.9.19 Visual Resources

Unavoidable adverse effects to visual resources (i.e., the viewsheds and naturalness of the landscape) would occur from oil and gas exploration and development through the introduction of vertical lines, regular spacing, reflectivity, and a greater spectrum of colors. These effects would be a direct result of oil and gas exploration and development activities and facilities such as seismic, ice roads/snow trails, ice pads, ice airstrips, drill pads, pipelines, and gravel roads.

4.9.20 Economy

Development of oil and gas resources may impair other economic activities, such as recreation. This is not expected to occur within NPR-A because of the number and location of recreational opportunities and level of recreational activity the area currently experiences. It may also impair development of other activities that do not now occur and are not foreseeable, such as tourism.

However, closing areas to oil and gas activities for even a decade may permanently prevent converting petroleum resources to governmental and other economic values described elsewhere. Lead times for exploration, permitting, and development activities are longer on the North Slope than in other areas in the U.S., and that time is further extended when exploration and development targets are further from existing infrastructure. Delays may make those resources economically or technically impossible to transport to market using existing or proposed pipelines.

Oil and gas development near communities and other areas will increase the cost of subsistence activities and affect local food security if not accompanied by increased employment and personal income in local communities. A lack of access to subsistence resources will increase transfer payments from one or more levels of government as residents seek financial assistance in place or as part of relocating to seek training and employment in Fairbanks, Anchorage, or elsewhere. A loss of a subsistence lifestyle may also result in social dysfunction and increased social ills, such as drug and alcohol abuse or violent crime, and require increased government expenditures for health care or law enforcement intervention. To the extent that subsistence resource harvesting requires more travel, there could be greater economic costs both to individuals (more gasoline and machine repairs) and government (more demands on health services). The costs to government are likely to be less than the revenues to all levels of government derived from oil and gas activities, but will limit funds available for other government activities. Effects to individuals are likely to be disparate, depending on individual employment and level of subsistence involvement or consumption. Mitigation measures may be undertaken to reduce effects to non-oil and gas activities, in addition to stipulations and best management practices identified elsewhere. Current training and mentoring programs are examples to improve local employment opportunities.

4.9.21 Public Health

Ongoing exploration and development activities will further the trend toward higher consumption of store-bought food and decreased reliance on and availability of traditional food. As a result the rates of diabetes, metabolic disorders, and associated chronic diseases will continue to increase. Because some displacement of subsistence resources and hunters is anticipated, injuries will increase as hunters' travel times and distances lengthen. The predicted influx of workers to villages along with disruption of subsistence harvests and ongoing acculturation will lead to increases in social pathologies, alcohol and drug abuse, and sexually transmitted infections.

[illegible]

4.9.18 Wilderness Characteristics

[illegible] would be a direct result of exploration and development [illegible] seismic, ice roads, snow trails, ice pads, ice airstrips, drill pads, pipelines, and gravel roads. The effect would be limited to the vicinity and/or timeframe of the activities, leaving most of the planning area unaffected. If it is determined in the [illegible] wilderness [illegible] Congress [illegible]

4.9.19 Visual Resources

Unavoidable adverse effects to visual resources [illegible] landscape [illegible] introduction of vertical lines, regular spacing, [illegible] These effects would be a direct result of oil and gas exploration and development activities and facilities such as seismic, ice and snow trails, ice roads, ice airstrips, drill pads, pipelines, and gravel roads.

4.9.20 Economy

Development of oil and gas resources may displace other economic activities, such as recreation. This is not expected to occur within NPR-A because of the number and location of recreational opportunities and level of recreational activity that are currently experienced. It may also impair development of other resources [illegible] that are now scarce and [illegible] such as tourism.

However, leasing areas for oil and gas activities [illegible] prevent [illegible] governmental [illegible] other economic values described elsewhere. Lead times for exploration, permitting, and development activities are longer on the North Slope than in other areas of the U.S., and they can be further extended when exploration and development targets are farther from existing infrastructure. Delays may make these resources uneconomic or technically infeasible to transport to market using existing or proposed pipelines.

Oil and gas development near communities and [illegible] could increase the cost of subsistence activities and offset local food security. These costs are offset by increased employment and personal income in local communities. A lack of access to subsistence resources will increase transfer payments from state, federal, and local levels of government as residents seek financial assistance in place of [illegible] choosing to seek training and employment in Fairbanks, Anchorage, or elsewhere. [illegible] a subsistence lifestyle may

Section 4.10:

Relationship between the Local Short-term Uses and Maintenance and Enhancement of Long-term Productivity

4.10 Relationship between Local Short-term Uses and Maintenance and Enhancement of Long-term Productivity

This section discusses the short-term effects of the plan, including the potential use of the NPR-A for oil and gas exploration and development activities, versus the maintenance and enhancement of potential long-term productivity of the NPR-A's environmental resources.

Short term in this subsection refers to the total duration of activities that could occur as a result of this plan, primarily oil and gas exploration and production activities, whereas long term refers to an indefinite period extending beyond the termination of the action. The specific impacts vary in kind, intensity, and duration according to the activities occurring at any given time. Initial non-oil and gas activities (e.g., overland moves and recreational and scientific camping) and oil and gas activities (e.g., seismic surveying and exploration drilling) generally result in short-term, localized impacts. Development drilling occurs sporadically throughout the life of an oil or gas field, but also results in short-term, localized impacts. Activities during the production life of oil and gas leases executed based upon the decision in the NPR-A record of decision following completion of this plan may result in chronic impacts over a longer period of time, potentially punctuated by more severe impacts as a result of accidental events. Facilities removal is also a short-term activity with localized impacts; the impacts of site clearance, however, may be longer lasting. Over the long term—several decades after completion of abandonment activities—natural environmental balances are generally expected to be restored, though that balance will not for all resources mean a return to the exact state prior to original disturbance.

Until more long-term study data become available, the long-term effects of chronic or major spills of hydrocarbons cannot accurately be projected. In the absence of these data, it should be assumed that chronic spills or a major large oil spill could result in decreased long-term productivity.

4.10.1 Air Quality

Air quality impacts from development, production, and transportation from each of the alternatives would be similar to those which have occurred historically. Short-term degradation of air quality related to exploration, construction, and operation would be the same as similar existing oil and gas exploration and production facilities. Since air quality is a renewable resource, when activities that produce emissions cease, the local air quality should return to its original natural condition.

4.10.2 Paleontological Resources

Because paleontological resources are nonrenewable, there is no difference between short-term and long-term impacts. The resource cannot endure most types of adverse impacts and maintain its integrity. Once disturbed, the materials and information of paleontological deposits may be permanently compromised. Any destruction of paleontological sites, especially ones determined to have significant scientific value, would represent unrecoverable losses. Any discoveries of paleontological resources as a result of surveys required prior to development of a lease would enhance long-term knowledge of the area and resources. Furthermore, once paleontological deposits (particularly vertebrate remains) are disturbed and exposed, natural erosion could accelerate the destruction of the materials. Exposed vertebrate fossils also are vulnerable to unauthorized collecting.

4.10.3 Soil Resources

Soils potentially affected by exploration practices cover very small areas, although up to 488,117 acres (Table 4–14 in Volume 2) of soil would be directly impacted in the short term during exploration and development for construction of pads and roads. This includes the soil that would be lost when new gravel quarries are developed (2,088 acres). Rehabilitation of soils after field abandonment could allow soils to eventually reestablish. While the formation of soils is a very slow process, short-term uses are projected to have very small long-term effects. Soils lost through the construction of permanent facilities (16,329 acres under Alternative D) would essentially be permanent.

4.10.4 Water Resources

Oil and gas exploration and development would result in both short-term and long-term effects to water resources. Construction activities that disturb stream banks or lake shorelines, temporarily block natural channels, and remove gravel would all cause short-term increases in erosion and sedimentation. Water removal could cause short-term changes in aquatic habitat. Permanent gravel roads and pads, airstrips, pipelines, and facilities constructed adjacent to or crossing streams and lakes would have long-term effects on water resources as long as they remained in place. Removal of these structures from streams and lakes after production ceased would restore drainage patterns and natural sedimentation processes. Long-term changes could occur where thermokarst erosion caused major changes in stream banks, and lake shorelines, and altered natural drainage patterns. Gravel mines and any associated erosional features caused by the mine would remain in place indefinitely. Oil spills would have both short- and long-term impacts to water quality depending on the size of the spill and the amount of oil recovered.

4.10.5 Vegetation

The effects of non-oil and gas activities on vegetation would be short term. However, the construction of well collars for exploration wells and the most severe impacts caused by vehicles during overland moves and seismic exploration would cause long-term effects on vegetation. All effects of oil-or gas field construction on vegetation would be long term, though new oil spills and dust and gravel spray from vehicular traffic on the gravel pads would not occur after field abandonment. The recovery time for vegetation from a spill could last several years (Jorgenson 1997, McKendrick 2000), but it is not known how long changes to plant communities as a result of dust effects would persist. Although research indicates that natural plant communities can be restored to gravel pads (McKendrick 1997), especially if some silt-loam soil is added to the substrate, the time until recovery of natural canopy cover would be so long that the impacts might be considered permanent from a human perspective. Therefore, the long-term productivity of these localized areas would be reduced, but these areas represent only 0.03 to 0.08 percent of the NPR-A. Placement of gravel drilling pads, roads, airstrips, staging areas, and docks, as well as construction of pipelines or the use of gravel mine sites, would permanently disturb or destroy vegetation unless sites were reclaimed.

4.10.6 Wetlands and Floodplains

The effects of non-oil and gas activities on wetlands and floodplains would be short-term. Construction of well cellars for exploration wells and the most severe impacts caused by vehicles during overland moves and seismic exploration would cause long-term effects on wetlands. All effects of oil and gas field construction on wetlands would be long-term, though new oil spills and dust and gravel spray from vehicular traffic on the gravel pads would not occur after field abandonment. Research indicates that natural plant communities can be restored to gravel pads (McKendrick 1997), but the time required until total recovery would be so long that the impacts might be considered permanent from a human perspective, thereby reducing the long-term productivity of these localized areas. Placement of gravel drilling pads, roads, airstrips, staging areas, and docks, as well as construction of pipelines or the use of gravel mine sites, would permanently disturb or destroy wetlands and block or alter natural drainage patterns unless sites were reclaimed. Removal of these structures from streams and lakes after production ceased would restore drainage patterns and natural sedimentation processes. Gravel mines and any associated erosional features caused by the mine within floodplains would remain in place indefinitely.

4.10.7 Fish

Most effects on fish and their habitats from oil and gas exploration and development would be short-term, as defined in section 4.9. Effects from activities that cause disturbance (e.g., seismic surveys or coastal vessel traffic), require temporary intrusion into habitats (e.g., water use or ice bridges across stream channels), or contribute to localized water contamination (e.g., point and non-point source pollution, including small oil spills) would end or dissipate after oil and gas operations ceased. Reduced productivity attributable to those activities would be expected to recover following the termination of oil or gas field operations. An exception would include fish passage impacts from permanent infrastructure that is intrusive into aquatic habitat (e.g., causeways and poorly engineered stream crossings for roads), which would continue to impact fish unless effectively removed. Decreased fish productivity would also persist beyond the life of oil and gas activities due to irreparable habitat alterations, such as altered stream geomorphology from poorly engineered stream crossings for roads or floodplain gravel mining. However, it is possible that properly abandoned floodplain gravel mines would result in increased fish productivity (due to additional spawning and overwintering habitat created) that could outweigh the negative impact from gravel mining (National Research Council 2003) if properly designed. Chronic spills of hydrocarbon pollutants in a localized area or a large or very large oil spill that reaches surface waters could result in prolonged negative effects that contribute to decreased long-term fish productivity.

4.10.8 Birds

Most effects on birds and their habitats from non-oil and gas activities and from oil and gas exploration and development would be short-term. Short-term, localized effects could occur in the event of an oil spill or gas release. Potential effects include mortality of individuals, physiological stresses in surviving individuals, reduction in the number of species in the affected area, changes in the reproductive ability of individuals, changes in the distribution of species or individuals, and changes in behavior. Long-term, cumulative effects could occur if recovery from the short-term effects extended beyond the production life of the field.

The potential effects of noise disturbance and terrestrial habitat alteration could also include short-term, localized effects such as mortality, stress, decreases in or redistribution of populations or species, and changes in survival patterns and reproductive success. Effects of oil and gas development on birds and their habitats would be long term (beyond the production life of the field); under some development scenarios, those effects could potentially have impacts at the population level. Long-term biological productivity could be lost from areas used as facility sites.

4.10.9 Terrestrial Mammals

Most effects on terrestrial mammals and their habitats from non-oil and gas activities and from oil and gas exploration would be short term. Short-term, localized effects could occur in the event of an oil spill, although it is expected that oil spills in the NPR-A would be small and thus not affect a large area. Potential effects include mortality of individuals, physiological stresses in surviving individuals, reduction in the number of species in the affected area, changes in the distribution of species or individuals, and changes in behavior or migration patterns. Long-term, cumulative effects could occur if recovery from the short-term effects extended beyond the production life of the field. The potential effects of noise disturbance and terrestrial habitat alteration could also include short-term, localized effects such as mortality, stress, decreases in or redistribution of populations or species, and changes in survival patterns. Effects of oil and gas development on terrestrial mammals and their habitats would be long term (beyond the production life of the field); under some development scenarios, those effects could potentially have impacts at the population level, although this has not been clearly documented for the Central Arctic Herd in the existing oil fields. Long-term biological productivity could be lost from areas used as facility sites.

4.10.10 Marine Mammals

Long-term productivity of marine mammal resources is unlikely to be significantly impacted by short-term uses. A large oil spill is the only action that is likely to have long-term effects on marine mammals after short-term development and production activities cease.

4.10.11 Special Status Species

4.10.11.1 Special Status Species of Plants

Sensitive plant species are by definition rare. Individuals within a population may have high reproductive success in terms of seed output, but their potential range expansion is likely limited by the narrow habitat requirements that cause them to be rare in the first place. Most impacts to these populations could be avoided by avoiding their locations during development. Some may be affected by overland move vehicles in winter, but these impacts would likely be sublethal and short-term. Thus uses of the land that cause these impacts would not affect the species long-term productivity.

4.10.11.2 Special Status Species of Birds

Most effects on special status species (particularly spectacled and Steller's eiders and yellow-billed loons) and their habitats from non-oil and gas activities and from oil and gas exploration and development would be short term. Short-term, localized effects could occur in the event of an oil spill or gas release. Potential effects include mortality of individuals, physiological stresses in surviving individuals, reduction in the number of species in the affected area, changes in the reproductive ability of individuals, changes in the distribution of species or individuals, and changes in behavior. Long-term, cumulative effects could occur if recovery from the short-term effects extended beyond the production life of the field. The potential effects of noise disturbance and terrestrial habitat alteration could also include short-term, localized effects such as mortality, stress, decreases in or redistribution of populations or species, and changes in survival patterns and reproductive success. Effects of oil and gas development on special status species and their habitats would be long term (beyond the production life of the field); under some development scenarios, those effects could potentially have impacts at the population level. Long-term biological productivity could be lost from areas used as facility sites.

4.10.11.3 Special Status Species of Terrestrial Mammals

There is likely very little land area within the NPR-A used by either the Alaska hare or the Alaska tiny shrew, if these species exist at all within the Reserve, so it is unlikely that either would suffer an adverse effect of oil or gas development. Moreover, surveys of a potential area of development (i.e., construction of permanent infrastructure) prior to permitting should determine the presence or absence of either species, and if presence were indicated development would likely be planned in a way to avoid impacts. Given these conditions, most remaining effects on these two species and their habitats from non-oil and gas activities and from oil and gas exploration would be short term. One exception to this would be in the event of an oil spill. Potential spill effects include mortality of individuals, physiological stresses in surviving individuals, and possibly reduced breeding success if resulting low population density decreases the odds of finding a suitable mate. Long-term, cumulative effects could occur if recovery from the short-term effects extended beyond the production life of the field. Long-term biological productivity could be reduced in areas affected by spills.

4.10.11.4 Special Status Species of Marine Mammals

Long-term productivity of special status whales and seals is unlikely to be significantly impacted by short-term production and development uses. A large-scale oil spill is the only action that is likely to have long-term effects on marine mammals after short-term development and production activities have ceased.

Most effects to polar bears associated with non-oil and gas and oil and gas activities would only result in short-term alteration of polar bear behavior for the duration of a specific activity, such as an overland move. In some cases, polar bear movements may be altered in response to oil and gas infrastructure. This impact would not be expected to extend beyond the life of oil and gas activities, as infrastructure would be removed prior to field abandonment. In rare instances, activities could affect individual polar bears through mortality events. These impacts, individually and cumulatively, would not be expected to affect the long-term productivity of polar bear populations within NPR-A. Long-term, population level impacts to polar bears are not expected as a result of actions described in this IAP/EIS, except in the case of a large oil spill. In the event of an oil spill, polar bears may avoid large portions of coastal habitat fouled by oil or be displaced from these areas by response activities, which may impact body condition, breeding success, or survival of individuals if they are excluded from feeding, resting, or denning areas for a prolonged period of time. Polar bears may also be directly oiled or ingest oiled prey items. Effects experienced by oiled bears may include mortality of individuals and sublethal physiological effects in surviving bears, which could reduce health and reproductive success. Under some scenarios, a large oil spill could result in population-level effects or long-term impacts to the food chain.

Aircraft, watercraft, and foot traffic not associated with permitted activities have the potential to disturb walrus if they do not maintain a sufficient distance from resting walrus or aggregations of walrus. Activities that take place too close to walrus aggregations at haul out areas may result in mortality events. Most oil and gas activities with potential to disturb walrus would avoid such disturbance through the use of stipulations and required operating procedures/best management practices that employ effective visual and noise buffers. Still, given the sensitivity of this species to disturbance by human activities, in rare instances disturbance could result in mortality of individual walrus or groups of walrus. Because disturbance events would be localized, long-term, population level impacts to walrus are not expected as a result of actions described in this IAP/EIS, except in the case of a large oil spill. In the event of an oil spill, walrus may be displaced from coastal haulout areas by response activities, which may impact body condition, breeding success, or survival of individuals if they are excluded from feeding or resting for a prolonged period of time. Hazing activities could cause trampling and separation of cows and calves. Walrus may also be directly oiled or ingest oil and oiled prey items. Effects experienced by oiled walrus may include direct mortality of individuals or sublethal physiological effects that could reduce health and reproductive success. Because walrus tend to aggregate, there is potential for a relatively large number of walrus to be oiled if a large oil spill were to enter the Chukchi Sea. A large oil spill could result in population-level effects or long-term impacts to the food chain.

4.10.12 Cultural Resources

Because cultural resources are nonrenewable, there is no difference between the effects of short-term and long-term impacts. Cultural resources cannot endure most types of adverse impacts and maintain their integrity. Historic structures could benefit from preservation and stabilization efforts prompted by nearby development. However, once disturbed, an archaeological deposit could never be returned to its original context. Any destruction of cultural resource sites represent long-term impact. Excavation of an impacted site to recover remaining data would generally result in the total destruction of the site, although the recovered data would, in most cases, effectively mitigate for loss of the site. Appropriate treatment of cultural resources as the result of surveys required prior to development of a lease would enhance knowledge of the history and early inhabitants of the region and serve to effectively mitigate further potential effects of activities in the area.

4.10.13 Subsistence

In the short term, the redistribution, reduction, or displacement of subsistence species could affect regional subsistence-harvest patterns. Such short-term effects would not be expected to have long-term consequences unless chronically imposed on the subsistence resource base of the region. Habitat destruction could cause a local reduction in subsistence species, a potential long-term impact to communities affected by such reductions. Increases in the amount of land used for infrastructure and development would reduce the amount of area suitable for subsistence hunting. Development along the coast could change the distribution of caribou in the summer, when the greatest numbers are harvested as the herds seek insect relief on beaches and in shallow lake and marine waters. Roads would increase access and competition for resources over the long term and could further affect subsistence harvests. The potential for user conflicts could increase in areas where current uses overlap.

4.10.14 Sociocultural Systems

Increased population, industrial activity, and minor gains in revenues and employment could potentially disrupt sociocultural patterns in Alaska Native communities in the short term. Income and employment allocation disparities could increase, causing intra-community conflict. Short-term effects on subsistence resources would disrupt social systems if these effects were to occur repeatedly (chronic) over the lifetime of oil and gas activities in the planning area and on the North Slope. Habitat destruction would locally reduce or displace subsistence species, a long-term cumulative effect on the regional subsistence economy. As a result, sociocultural values and cultural institutions would be affected. Activities or policies that act against the values of the Iñupiat residents of the region would increase social stress and concerns in the community.

4.10.15 Environmental Justice

Any impact on subsistence resources that would have a chronic effect on the sociocultural system or subsistence resources over the lifetime of oil and gas activities would disproportionately affect the Iñupiat people. Such an effect would only be expected to occur in the event of long-term population and productivity effects to caribou, fish, marine mammals, or water birds.

4.10.16 Recreation Resources

Short-term use of portions of the NPR-A for oil and gas development could affect the long-term use and value of recreation resources. If gravel roads and airstrips were not removed or rehabilitated, then recreation opportunities in that area could be enhanced by providing access. However, scenic quality and unconfined recreation opportunities would be negatively impacted by the presence of the gravel roads and airstrips.

4.10.17 Wild and Scenic Rivers

Most effects on eligible rivers from oil and gas exploration and development would be short-term, as defined in section 4.10. Effects from activities that cause disturbance (e.g., seismic surveys or coastal vessel traffic), that involve temporary intrusion into river areas (e.g., water use or ice bridges across stream channels), or contribute to localized water contamination (e.g., point and non-point source pollution, including small oil spills) would end or dissipate after oil and gas operations ceased. Impacts to free-flow, water quality and outstandingly remarkable values attributable to those activities would be expected to recover following the termination of oil or gas field operations. An exception would include impacts from permanent infrastructure that might cross or parallel eligible rivers (e.g., causeways and stream crossings for roads or pipelines), which would continue to impact river values until effectively removed. It is possible that some impacts, such as altered stream geomorphology from poorly engineered stream crossings for roads or floodplain gravel mining could persist even after all improvements were removed. Chronic spills of hydrocarbon pollutants in a localized area or a large or very large oil spill that reaches eligible river areas could result in prolonged negative effects.

4.10.18 Wilderness Characteristics

Short-term use of portions of the NPR-A for oil and gas development could affect the long-term use and value of wilderness characteristics. If gravel roads and airstrips were not removed or rehabilitated, and it is determined in the future that these activities impair wilderness characteristics, the areas would be excluded from the Lands with Wilderness Characteristics Inventory. Scenic quality, naturalness, and primitive and unconfined recreation opportunities, which are essential to wilderness characteristics, would be negatively impacted by the presence of these structures.

4.10.19 Visual Resources

Short-term use of portions of the NPR-A for oil and gas development could affect the long-term value of visual resources. Rehabilitation, removal, and revegetation of pads, roads and facilities would eventually cause the viewshed to resemble a more natural condition. However, it is possible that the full value of the original scenic quality and viewshed would not be regained. Visual resources could still be negatively impacted by any remnants of oil and gas activities and by changes to the original landscape particularly to line, color, texture and form characteristics.

4.10.20 Economy

The North Slope Borough is likely to close its major oil and gas boom-bust cycle before 2100. The boom began in the 1970s with initial development. A smaller bust occurred in the mid-1980s during a worldwide glut of oil supply. Whatever additional increases or decreases in local activity, at some point it will not be economically efficient to transport oil or gas from the North Slope. This is expected to occur before 2100 for current and future North Slope oil and gas activities outside the NPR-A, and any activities occurring within the NPR-A (Thomas et al. 2009). In this sense, beyond 2100 can be defined as the long term and the next roughly 90 years are the short term. The short-term oil and gas production provides revenues and personal income to use for investment in economic diversification and infrastructure, or to set aside as permanent funds to assist future generations.

In the more classical sense, where short term is described as 1 to 5 years and long term is beyond 5 years, NPR-A oil production is important to maintain North Slope production at levels sufficient to operate Trans-Alaska Pipeline System and enhance domestic production and national security. Future NPR-A gas production will be important as a transition fuel to maintain U.S. economic activity in anticipation of establishing adequate renewable fuel supplies or becoming less energy dependent. The short-term opportunities to prepare for natural gas production will encourage construction of one or more gas pipelines to increase long-term productivity.

In addition, roads and other infrastructure developed for short-term oil and gas activities may benefit residents in the long term, to 2100 and beyond. Other resource uses, such as recreation, are expected to remain at approximately recent levels.

4.10.21 Public Health

In the case of public health, "long-term productivity" can be defined as the ability of the population to experience good health over the long term, without that health being affected by systematic barriers or by externally driven changes in the local physical or social environment. With oil and gas exploration and development, local short-term uses will impact public health through environmental exposures (such as dust or noise) and displacement of hunters or animals (leading to dietary changes and increased risk of injuries and accidents). Such impacts, however, will subside as local industrial uses end and as traditional land use patterns and subsistence resources rebound.

Nevertheless, dietary change and acculturation may persist long after the termination of local short-term activity. The transition from a traditional diet towards one more heavily dependent on store-bought foods is pervasive and persistent in many aboriginal communities and is only partly a result of oil and gas exploration and development activity. As traditional skills, knowledge, and food sharing networks erode, the ability for a community to revert to subsistence diets will be impaired. The longer local impacts on subsistence persist, the more they will add to long-term impacts on health by way of diet and nutrition.

The large-scale socio-economic changes that will occur over the lifetime of activities that could be authorized according to the NPR-A IAP will result in both positive and negative impacts on public health. Increases in revenues and employment may provide better development of and access to improved health care, as well as other infrastructure that supports public health such as improved sanitation and improved education of prevention and treatment methods. However, local intense injections of cash and influxes of outside workers may cause increases in social pathology and sexually transmitted infections. Although the intensity of these impacts will abate as the immediate actions come to an end, there may be some long-term adverse effect on public health. Because social pathology (such as alcohol and drug abuse and domestic violence) adversely impact early childhood environments they can result in lifelong health effects and increase the prevalence of social dysfunction in subsequent generations.

The positive local short-term health impact of economic activity, which accrues through employment and revenue will also recede as exploration and development activity end. Although investments and economic development may mitigate the loss of oil and gas activity from the region, eventual increases in unemployment and reductions in the tax base will affect the affordability of subsistence activity, the provision of essential services, and the prevalence of social pathology and alcohol and drug use.

and cultural sectors of [illegible] NPR-A [illegible] will be [illegible]

In addition, roads and other infrastructure [illegible] oil and gas activities may be [illegible] recreation, are expected to [illegible]

4.10.2 Public Health

In the case of public health, "long-term sustainability" can be defined as the ability of the population to experience good health over the long term, without that health being affected by systematic barriers or by externally driven changes [illegible] environment. With oil and gas exploration and development, local short-term [illegible] impact public health [illegible] displacement [illegible] injuries and accidents [illegible] and as traditional land use [illegible]

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Section 4.11:

Irreversible and Irretrievable Commitment of Resources

4.11 Irreversible and Irretrievable Commitment of Resources

Irreversible or irretrievable commitments of resources refer to impacts or losses to resources that cannot be reversed or recovered. Examples are the extinction of a species or the permanent conversion of a vegetated wetland to open water. In either case, the loss is permanent. The following section identifies irreversible and irretrievable commitments of resources that would occur if leasing occurred and resulted in oil and gas exploration, development, and production.

4.11.1 Air Quality

Air quality would be affected by well drilling, construction activities, and production. These effects would occur only during the life of the field(s). Therefore, no irreversible or irretrievable effects on air quality would occur.

4.11.2 Paleontological Resources

Because paleontological resources are nonrenewable, any impacts would render the resource disturbance irreversible and the integrity of the resource irretrievable.

4.11.3 Soil Resources

Soils covered by gravel pads, roads, landing strips, and other infrastructure facilities would be lost with respect to their value (such as a medium for the growth of vegetation) as soils. Rehabilitation of soils after field abandonment could allow soils to eventually reestablish. Soil in disturbed areas could reestablish over time, but soil development in cold climates is a very slow process. The desirable mitigation for soils would be to minimize the total area lost by minimizing the area of surface disturbance, best management practices, and use of shared facilities. Several of the lease stipulations and required operating procedures/best management practices are designed to reduce the amount of soil impacted by exploration and development activities. Areas adjacent to disturbed soils may be affected by thermokarst and would also be permanently removed from future productivity.

4.11.4 Water Resources

Impounded water along roadways could result in permanent water bodies which would remain after the roads or other structures were removed, post abandonment. Other altered natural drainage patterns could last long after the life of the field. While there would be no irreversible or irretrievable effect on water resources, the restoration of the natural drainage could take years after the field was abandoned, equipment removed, and the roads and pads rehabilitated. Gravel mine sites would create permanent water bodies, which could provide fish habitat if connected to streams.

4.11.5 Vegetation

Permafrost-related geomorphic processes occurring on the Arctic Coastal Plain create a constantly changing landscape that influences successional patterns in plant communities.

Most plant communities of Alaska's North Slope are well adapted to these frequent changes (Billings and Peterson 1980, Bliss 2000, Funk et al. 2004). Therefore, changes in plant communities resulting from dust or snowdrift accumulations or the formation and draining of impoundments would not be considered irreversible. However, the burial of vegetation under gravel fill could be considered an irretrievable commitment of vegetation resources, as the potential recovery of vegetation on these pads could take 25 to 30 years or more (McKendrick 1997, 2000).

4.11.6 Wetland and Floodplains

Changes in plant communities resulting from dust or snowdrift accumulations would not be considered irreversible. Burial of wetlands under gravel fill could be considered an irretrievable commitment of vegetation resources, as the potential recovery of vegetation on these pads could take 25 to 30 years or more (McKendrick 1997, 2000). Impounded water along roadways could result in permanent waterbodies, which could remain after the roads or other structures were removed. Other altered natural drainage patterns could last long after the life of the development. While there would be no irreversible or irretrievable effect on floodplains unless gravel structures were left intact, the restoration of the natural drainage could take years after an oil or gas field was abandoned, equipment removed, and the roads and pads rehabilitated. Gravel mine sites would create permanent water bodies, which could provide fish habitat if connected to streams.

4.11.7 Fish

Some fish habitat impacts resulting from oil and gas activities would be irreversible. This would primarily include those that cause substantial changes in stream geomorphology. For example, loss of pool habitat due to channel widening that could occur downstream from floodplain gravel mines or poorly engineered stream crossings for roads. If permanent infrastructure that is intrusive into aquatic habitat is removed effectively after field abandonment (e.g., causeways and road stream crossings that block fish migrations), permanent fish habitat loss should be very limited. The loss of individual fish could occur from any number of oil and gas exploration and development impacts; however, these losses would not be expected to have an effect on fish at the population level.

4.11.8 Birds

It is possible that birds could be subjected to the direct and indirect effects of noise and movement of motor vehicles and aircraft, other human activities, oil spills, natural gas blowouts, or losses and deterioration of habitat because of facility developments. It is likely that such effects would lead to some permanent (irreversible) losses of individuals and in some rare cases significant proportions of some populations.

4.11.9 Terrestrial Mammals

It is possible that caribou and other terrestrial mammals could be subjected to the direct and indirect effects of noise and movement of motor vehicles and aircraft, other human activities, oil spills, natural gas blowouts, or losses and deterioration of habitat because of facility developments. It is likely that such effects would lead to some permanent (irreversible) losses of these resources.

4.11.10 Marine Mammals

It is possible that some marine mammals could be subjected to the direct and indirect effects of noise (including aircraft), oil spills, and the movement of vessels servicing oil and gas and community development. Such effects could lead to some permanent (irreversible) losses of individual animals, though not detectible at the population level. If a marine mammal reached minimal population levels due to climate change, it is possible that permanent irreversible losses to the species at the population level could occur if a large-scale oil spill occurred.

4.11.11 Special Status Species

4.11.11.1 Special Status Species of Plants

Since populations of sensitive plant species can be avoided during development, there should be no irreversible or irretrievable commitment of these resources.

4.11.11.2 Special Status Species of Birds

It is possible that special status species (particularly spectacled and Steller's eiders and yellow-billed loons) could be subjected to the direct and indirect effects of noise and movement of motor vehicles and aircraft, other human activities, oil spills, natural gas blowouts, or losses and deterioration of habitat because of facility developments. It is likely that such effects would lead to some permanent (irreversible) losses of these resources.

4.11.11.3 Special Status Species of Terrestrial Mammals

Despite predevelopment surveys for and subsequent avoidance of any discovered habitat of the Alaska hare and the Alaska tiny shrew, it is possible that some populations of one or both species could be subjected to the direct and indirect effects of human activities, oil spills, natural gas blowouts, or losses and deterioration of habitat because of facility developments. It is likely that such effects would lead to some permanent (irreversible) losses of hare or shrew habitat or populations.

4.11.11.4 Special Status Species of Marine Mammals

It is possible that some special status whales and seals could be subjected to the direct and indirect effects of noise (including aircraft), oil spills, and the movement of vessels servicing oil and gas and community development. Such effects could lead to some permanent (irreversible) losses of individual animals, though not likely detectible at the population level.

Despite efforts to avoid impacts to polar bears and Pacific walrus, some polar bears and walrus will likely be directly and indirectly affected by human activities and losses of habitat or decreased habitat quality. It is also possible that some polar bears and walrus will be impacted by oil spills. These impacts could lead to some permanent (irreversible) loss of individual polar bears and walrus through mortality or reduced reproductive success. Except in some scenarios resulting from a large oil spill, no population level effects would be expected for either species.

4.11.12 Cultural Resources

Cultural resources are nonrenewable, so any impacts would be irreversible, and the integrity of the affected resource would be irretrievable. Since most known cultural resources exist in a surface or near-surface context, burial by the construction of a gravel pad or road, while possibly not damaging in itself, would affect the cultural resource upon removal of the gravel during site remediation. If subsurface cultural resources were encountered, as during the development of a gravel mine site, such resources could be damaged or destroyed. The loss of such cultural resource information would be irreversible and irretrievable. Salvage archaeology to recover remaining site data would generally result in the total destruction of the site, although the recovered data would, in most cases, effectively mitigate for loss of the site. Any discovery of cultural resource data as a result of surveys required prior to development of a lease would enhance long-term knowledge. Overall, such finds could help fill gaps in our knowledge of the history and early inhabitants of the area.

4.11.13 Subsistence

Many important aspects of Iñupiaq society and culture are centered on subsistence activities. Virtually every family in North Slope coastal communities participates in the hunting of the bowhead whale and the sharing of its meat and maktak. The activities associated with harvest of caribou, fish, birds, wolf, wolverine, and seals are only slightly less important to the cultural integration of the region as a whole, but they are of equal importance to the inter- and intra-community social organization, nutritional input, cultural identity, and the domestic economies of most households. The reduction or loss of the ability to harvest sufficient quantities of these resources would be an irreversible and irretrievable loss to the Iñupiaq diet, to Iñupiaq traditional practices of sharing and reciprocity, and to fundamental aspects of Iñupiaq identity. If subsistence users were to abandon traditionally used harvest areas because of legal or perceived regulatory boundaries or contamination concerns at or near an oil or gas development, this abandonment would contribute to a loss of access, affecting the connection of Iñupiaq subsistence users to traditional use areas.

4.11.14 Sociocultural Systems

Disruption of the traditional harvest of bowhead whales and caribou could constitute an irreversible and irretrievable loss to Iñupiaq social and cultural values. The alienation of Iñupiaq subsistence users from their homelands would be an irreversible and irretrievable commitment of resources, as land use patterns have shown that when oil and gas development activities take place in an area, other land uses are curtailed and land users excluded (Brown 1979, Pedersen et al. 2000). This connection to the land is one factor that constitutes Iñupiaq identity, not least in terms of how one identifies oneself in Iñupiaq society by area of residence, such as Kuukpikmiut, a person of the Colville River area. The contribution of oil and gas development in the NPR-A to the cumulative consequences of offshore and onshore energy development could, in conjunction with other processes of social change in the long term, lead to social and cultural conflicts within and between communities and contribute to the compromise of Iñupiaq value systems. If the Iñupiat were to lose access to traditional use areas and culturally valued sites in the planning area, or avoid them for cultural reasons, then sociocultural patterns could be affected; there would be a loss of continuity between generations and changes in sharing and reciprocity within and between communities as a result of a reduction in subsistence harvests.

4.11.15 Environmental Justice

Long-term population and productivity effects to caribou herds, fish populations, or waterfowl from oil and gas development could produce irreversible and irretrievable effects to subsistence resources. These effects would translate into effects on Alaska Native minority populations and thus raise environmental justice issues.

4.11.16 Recreation Resources

There would be no irreversible and irretrievable commitment of recreation resources. Proper rehabilitation and removal of development pads and other structures would restore the perception of a natural environment.

4.11.17 Wild and Scenic Rivers

Some potential impacts to eligible river values resulting from oil and gas activities might be irreversible. This would primarily include those that cause substantial changes in stream geomorphology, and could result from flawed design or construction of improvements. For example, loss of a good channel for river boats could result from channel widening that could occur downstream from floodplain gravel mines or poorly engineered stream crossings for roads. If permanent infrastructure that is intrusive into eligible river areas is well designed and removed effectively after field abandonment then irreversible or irretrievable impacts to river values should be very limited. In general, future eligibility of rivers in the NPR-A as potential additions to the national wild and scenic rivers system would not be affected in the long term.

4.11.18 Wilderness Characteristics

Wilderness characteristics would be forgone in those areas affected by development for the duration of the development, rehabilitation, and recovery. The degree of the impacts to wilderness characteristics would depend on the level of success of rehabilitation and recovery efforts after completion of petroleum production. It is possible that the effects would be irreversible and irretrievable.

4.11.19 Visual Resources

There would be no irreversible or irretrievable commitment of visual resources. Proper removal, rehabilitation, and revegetation of development pads and other facilities would restore the perception of a natural environment. To the casual observer, viewsheds would appear natural.

4.11.20 Economy

There is no commitment of federal economic resources that would be irreversible or irretrievable. Issuing leases or permits would result in financial commitments by lessees and permittees to comply with the BLM and other requirements, including bonding for final abandonment occurring at the end of any project, to protect federal financial resources.

4.11.21 Public Health

Any enduring change in community health status, or any chronic or fatal illness in an individual, constitutes an irreversible or irretrievable commitment of resources. Increases in chronic disease prevalence, which may occur as a result of the plan alternatives include increases in diabetes and related metabolic disorders, increases in cardiovascular and cerebrovascular diseases, and, if contaminants from oil and gas development enter the food chain at substantial levels, increases in cancer, endocrine disorders, and neurodevelopmental delay. Long-term, community-wide increases in social pathology might result from the alienation of subsistence uses from their homelands and traditional subsistence way of life. At an individual level, mortality from chronic metabolic disorders, cancer, suicide, infectious diseases, exacerbations of chronic respiratory disease, violence, and unintentional injury, to the extent that the plan may contribute to increases in these problems, would constitute an irreversible and irretrievable commitment of resources.

4.11.22 Oil and Gas Resources

Oil and gas resources are expected to be leased, discovered, developed, and produced as a result of leasing in the NPR-A. The oil and gas resource estimates for each alternative considered in this plan are presented in Table 4–15 in section 4.2.1.2 (Volume 2). For the scenario with highest development (Alternative D), it is estimated that approximately 761 million barrels of oil and 18.363 trillion cubic feet of gas would be available for production. Should these resources be produced, they would be irretrievably consumed and, in the unlikely event of an oil spill or a gas release, the oil spilled or the gas released would be irretrievably lost.

Section 4.12:

Low-probability, Very Large Oil Spill

4.12 Low-probability, Very Large Oil Spill

4.12.1 Introduction

This section discusses very large oil spill occurrence frequencies from a loss of well control escalating into a long duration blowout and the potential effects of a very large oil spill in the National Petroleum Reserve-Alaska. In this IAP/EIS, the size of a very large spill is defined as greater than or equal to 120,000 barrels of oil. A very large oil spill is a low-frequency event with the potential for severe effects. Because very large spills from blowouts happen so infrequently, there is limited historical data for the BLM's use in statistical analysis and prediction.

The BLM reviewed those sources where accidental crude spills could occur and determined well-control incidents escalating into long duration blowouts have the potential for the largest spill volumes, assuming all primary and secondary safeguards fail and the well does not collapse in on itself and stop flowing. The loss of the entire volume in an onshore pipeline between two valves would result in less volume spilled than a long duration well-control incident with high flow rates. For purposes of analysis, the BLM examined a well-control incident that escalates into a blowout with a long duration flow (15 days) of crude oil.

4.12.1.1 Well-control Incidents

This section summarizes information about historical well-control incidents and incidents which escalate into blowouts for the onshore Alaska North Slope, the offshore Alaska Outer Continental Shelf and Canadian Beaufort, U.S. Outer Continental Shelf, and finally onshore worldwide.

Onshore Alaska North Slope Historical Well-control Incidents and Modeled Frequencies

The historical record of onshore Alaska North Slope well-control incidents escalating into blowouts is discussed in USDOI BLM and Minerals Management Service (1998, 2003) and USDOI BLM (2005, 2008) and is incorporated by reference and briefly summarized. Of the 11 reports 6 were well-control incidents and 5 escalated into blowouts, 10 were gas and 1 was oil (National Research Council 2003). The oil blowout in 1950 resulted from drilling practices that are not relevant today. A third study confirmed that no crude oil spills greater than or equal to 100 barrels from blowouts occurred from 1985-1999 (Hart Crowser, Inc. 2000). No very large oil spills have occurred on the Alaska North Slope while producing 16.4 billion barrels from 1977-2010.

Scandpower (2001) used statistical blowout frequencies modified to reflect specific field conditions and operative systems at Northstar. This report concludes that the blowout frequency for drilling the oil-bearing zone is 1.5×10^{-5} per well drilled. This compares to a statistical blowout frequency of 7.4×10^{-5} per well (for an average development well). This same report estimates that the frequency of oil spill quantities per well drilled for Northstar for a spill larger than 130,000 barrels is 9.4×10^{-7} per well.

Historical Outer Continental Shelf and Canadian Beaufort Exploration Well-Control Incidents

No exploratory drilling well-control incidents have occurred on the Alaskan Outer Continental Shelf while drilling 98 wells (84 industry wells and 14 Continental Offshore Strategic Test wells). Thirty-five of those 98 exploratory wells were drilled in the Arctic Outer Continental Shelf. One exploration-drilling blowout of gas has occurred on the Canadian Beaufort Sea. Up to 1990, 85 exploratory wells were drilled in the Canadian Beaufort Sea, and one shallow-gas blowout occurred. A second gas well-control incident occurred at the Amaluligak wellsite with the Molikpaq drill platform but was not included. This incident resulted in a gas flow through the diverter, with some leakage around the flange. The incident does not qualify as a blowout by the definition used in other databases and, therefore, was excluded from the counts of blowouts (Devon Canada Corporation, 2004).

Industry has drilled 223 exploration wells in the Pacific Outer Continental Shelf, 46 in the Atlantic Outer Continental Shelf, 15,138 in the Gulf of Mexico Outer Continental Shelf, and 84 in the Alaska Outer Continental Shelf, for a total of 15,491 exploration wells. During this period, there were 77 well-control incidents associated with exploration drilling. Of those 77 well-control incidents, 14 resulted in oil spills. Thirteen of these 14 ranged in size from 0.5 barrel to 200 barrels, for a total 354 barrels. The Deepwater Horizon event of April 2010 was the only large Outer Continental Shelf spill; it is estimated to have resulted in a spill of 4,900,000 barrels (Lubchenco et al. 2010). It is recognized that the frequency for a large or very large oil spill on the Outer Continental Shelf from a well control incident is very low. From 1971-2010 the Deepwater Horizon event has been the only large/very large oil spill from a blowout during exploratory and development/production operations on 41,781 Outer Continental Shelf wells, or 2.39×10^{-5} per well.

Onshore Worldwide Incidents

Internationally, from 1965 through 2010, four onshore oil well-control incidents, resulting in an oil spill of greater than or equal to 120,000 barrels, were identified from the peer reviewed and “gray” literature (Appendix G, Table G–5). The largest onshore blowout, called the Lakeview gusher, was estimated to be 9.4 million barrels, half of which was estimated to reach the environment or evaporate. The Lakeview gusher incident in 1919 in California is not considered in this analysis because drilling techniques have evolved substantially since it occurred. There were roughly 1.066 trillion barrels of oil produced worldwide from 1965–2010 (British Petroleum 2011). The BLM uses production because the number of exploration wells worldwide is not readily available. These data provide an approximate occurrence rate of about one very large oil spill from an onshore blowout worldwide for approximately every 270 billion barrels of oil produced worldwide. Using international data increases the size of the data set and is more likely to capture rare events. However, it assumes that non-U.S. events are relevant to U.S. events to the extent that technology, maintenance, operational standards, and other factors are equal; but this may not be the case.

4.12.2 Blowout Assumptions

The closest field equivalent for NPR-A is Alpine. For purposes of analysis the highest flow rate for Alpine was used. The Alpine flow rate is much higher than flow rates have been in the 30 exploration wells drilled in NPR-A. In the Oil Discharge Prevention and Contingency

Plan for the Alpine field, ConocoPhillips estimates a 7,500-barrels-per-day flow rate for 15 days, for a total of 112,500 barrels. In this analysis, the 7,500 barrels per day flow rate is used, rounded up to 8,000 barrels per day for a total of 120,000 barrels for the 15-day period.

The potential impacts on specific resources are presented below. In each resource-specific analysis, the blowout hypothetically occurs in an area sensitive to that particular resource and releases crude oil into the environment for 15 days. For the scenario, the analyst places the blowout spill in the location most susceptible to the resource. The general environments into which the oil could discharge are tundra, ponds, lakes, creeks, rivers, and lagoons. The blowout could occur at any time of the year. The receiving environment could be solid ice, broken ice, or open water, as well as snow and open ground.

The following blowout assumptions are taken from oil discharge prevention and contingency plans from facilities on the Alaskan North Slope (Phillips Alaska, Inc. 2001; BP Exploration (Alaska), Inc. 2000, 2001a, b).

- The crude oil is assumed to be similar in composition to "Alpine field" crude oil.
- The theoretical facility is a 5-acre gravel pad.
- The gas/oil ratio ranges from 400 to 2,200 standard ft^3 per barrel.
- The gas flow rages from 2 million to 20 million standard cubic feet per day.
- The crude oil and gas mixture rises into the air at an average rate of 300 barrels per hour (8,000 barrels per day divided by 24 hours).
- Oil droplets fall to the gravel pad and surrounding area in the direction of the prevailing wind.
- Assuming an Alpine field-like crude oil, approximately 30 percent of the 120,000 barrels evaporates into the air, leaving 84,000 barrels on or adjacent to the gravel pad and surrounding area.

The following figures are based on Alaska Clean Seas (2010) Tactic T-6, assuming a 6.3-inch pipe and the gas/oil ratio shown above. The highest gas/oil ratio results in the higher values below. Of the oil falling to the surrounding environment:

- Eighty percent of the oil land on the ground within 300 feet (lowest gas flow) to 3,600 feet (highest gas flow) from the source, in a fallout width of 100 feet (lowest gas/oil ratio) to 400 feet (highest gas/oil ratio) wide; and
- Ten percent of the oil lands on the ground within 3,600 feet (lowest gas/oil ratio) to 33,000 feet (highest gas flow) from the source, in a fallout width of 400 feet (lowest gas/oil ratio) to 2,000 feet (highest gas flow) wide.

After 15 days from the start of the spill:

- 3,400 barrels remain on the 5 acre gravel pad;
- 38,600 barrels have drained from the gravel pad into the environment; and
- 42,000 barrels have fallen to the surrounding environment (2,800 barrels per day).

4.12.3 Behavior and Fate of a Blowout Oil Spill during Various Seasons

During a blowout, oil would fall to the pad and surrounding area in a scattered pattern. Some of the oil falling to the pad would drain to the surrounding area. How the oil would behave after that would be dependent upon the season.

4.12.3.1 Winter

For a spill occurring during winter, oil would spread mainly on the surface of snow cover, ice, and/or frozen soil. No oil would enter open water as long as the ice remained solid. There would be little or no change in the oil's physical properties at very low temperatures and when buried under a snow cover. Blowing snow would tend to combine with pooled oil until the oil was effectively saturated with snow crystals.

The oil would not penetrate any ice surface. It would spread mainly on the surface of the frozen soil. It is unlikely to penetrate the lower layers of soil because the seasonal thawed layer would be absent (Chuvilin et al. 2001).

4.12.3.2 Fall Freeze-up

Broken ice occurs in the planning area during fall freeze-up and spring breakup. The scenario for this analysis assumes that oil would fall to the broken ice in a scattered pattern and would drain from the pad into broken ice in tundra ponds, lakes, streams, rivers, or lagoons. The ice would contain the oil somewhat and reduce spreading. Unless the oil was frozen into the ice, the evaporation rate would not change. Dispersion and emulsification rates would be lower in broken ice than in open water.

For a spill occurring during fall freeze-up, the oil would freeze into the ice and slush before ice sheeting occurred. Winds and storms could break up and disperse the ice and oil until the next freezing cycle. These freezing cycles can be hours or days. In late spring and summer, this unweathered oil would melt out of the ice at different rates, depending on when the oil was frozen into the ice. In first-year ice, most of the oil spilled at any one time would percolate up to the ice surface over about a 10-day period. About mid-July, the oil pools would drain into the water. Thus, oil could be pooled on the ice surface for up to 30 days before being discharged from the ice surface to the water surface. The pools on the ice surface would concentrate the oil, but only to about 2 mm thick, allowing evaporation of approximately 5 percent of the oil—the part of the oil composed of the lighter, more toxic components of the crude. By the time the oil was released from the melt pools on the ice surface, evaporation would have almost stopped, with only an additional 4 percent of the spilled oil evaporating during an additional 30 days on the surface of the pond, lake, creek, stream, or river.

4.12.3.3 Spring Thaw

For analysis, it is assumed that a spill occurring during spring thaw and sea ice breakup would have the same behavior and effects as a summer or open-water spill. At spring thaw, the ice concentrations are variable. With high concentrations of ice, oil would spread between ice floes. As the ice concentrations eventually decreased to less than three-tenths of the water surface area, the oil on the water would behave as an open-water spill, with local oil patches temporarily trapped by the wind against ice floes. Oil on the ice floes would move with the ice as it responded to currents generated by the wind (S.L. Ross Environmental Research Ltd. 1998).

4.12.3.4 Summer

This scenario assumes that oil would drain from the gravel pad onto the tundra and/or open water, including lakes, ponds, creeks, streams, rivers, or lagoons. If oil were to fall on a water surface, the oil would move with the direction of flow and/or the winds. On the tundra, during the summer, the oil would spread less because of the cover of vegetation. Oil could penetrate the lower layers of soil because of their thawed condition. Rain could also increase the penetration of oil into the soil. The oil could spread laterally if it reached a permafrost lens or layer (Chuvilin et al. 2001).

4.12.4 Effects of a Low-Probability, Very Large Oil Spill

4.12.4.1 Air Quality

A very large (greater than or equal to 120,000 barrels) oil spill would affect air quality locally and temporarily. Potentially harmful emissions of criteria pollutants (see Volume 1, section 3.2.2.4 and Table 3-2) may occur resulting in significant levels of NO_x, CO, SO_2, particulate matter, and volatile organic compounds (VOCs). The impact is likely to be greatest following an initial blowout. Air quality impacts would occur from evaporation (VOC) and burning (CO, NO_x, SO_2, and particulate matter) associated with the oil spill or with oil-spill clean-up activities.

The scenario for a very large oil spill assumes that the release of crude oil would continue for 15 days. Therefore, VOCs would continue to be released from the spilled oil for that length of time. The VOC concentrations are anticipated to be low, would normally be limited to an area close to the spill, and would evaporate completely soon after the spilling ceased. The use of burning to mitigate spilled oil would reduce VOC emissions, but would create CO, NO_x, and possibly SO_2 emissions. Winds would encourage evaporation, and further disperse the VOC or combustion concentrations. Therefore, air quality effects from a very large oil spill should remain localized and temporary (USDOI BLM 2008).

4.12.4.2 Paleontological Resources

Impacts to surface and near-surface paleontological deposits would likely be greater for a summertime spill than for one that occurred during the winter. While contamination of the deposit could render much of the data recovery valueless, the clean-up procedures would create even greater impacts. Since paleontological resources are nonrenewable, the effects could be substantial.

4.12.4.3 Soil Resources

Spills can create direct toxic effects to soil productivity, and depending on the season, soils can also be impacted by compaction and thermokarst during cleanup activities. There is no history of the effects of a very large spill of crude oil on North Slope soils. Overall, past spills (of much smaller volumes) on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown good potential for recovery, with wetter areas recovering more quickly (Jorgenson 1997, McKendrick 2000, National Research Council 2003). It is estimated that a spill of 120,000 barrels would cover up to 1,500 acres, with 80 percent of the oil falling out on less than 30 acres. Oil spills of any size could impact soils by altering vegetation. From these numbers it is assumed that most of the vegetation within a spill area would be impacted. The oil alone would decrease plant growth, but oil spills probably would leave the surface organic mat intact. Oil may be held within the organic mat but biological breakdown would be very slow due to limited microbial activity in the cold climate. Spill cleanup, however, would be more likely to damage soils. Cleanups are not always well controlled; heavy traffic and digging are common and can result in damaged soils. Cleanup of oil spills would mitigate impacts to soils only if the clean-up methods and operations were very carefully controlled to minimize surface disturbance.

4.12.4.4 Water Resources

A very large crude-oil spill could have serious impacts to streams and lakes. While the petroleum residue from a spill could be flushed from most streams within a few years, the impacts to lakes and ponds could persist for decades. Additionally, a very large spill could saturate the tundra mat with oil, limiting the amount of crude oil that was recovered, and considerably lengthening the time over which impacts could occur. A spill that occurred in the winter could have similar impacts, although the snow and cold temperatures would retard the crude-oil runoff into the watershed as the snow soaked up the oil and somewhat limit the contamination. A spill that occurred during spring breakup or fall freeze-up could have the greatest impacts, since it would be extremely difficult, if not impossible, to contain the spill when ice was either breaking apart or forming into semi-solid slush pans or jumble ice. Spill cleanup in the watershed would involve containing the spill, diverting or isolating it within the water body, skimming off the oil, and treating the remaining oil-contaminated water and sediments. Prevention and rapid response with adequate removal equipment would minimize effects.

For spills during frozen conditions, it is anticipated that oil would not reach open water. Following contaminated snow and ice removal, water quality impacts from the residual oil would be very limited in extent. However, even small quantities of oil remaining after cleanup could result in lethal and sublethal toxicity levels in waters within the spill area for approximately a decade.

During summer, flat coastal tundra develops a dead-storage capacity averaging 0.5 to 2.3 inches (Miller et al. 1980) that would retain 300 to 1,500 barrels of oil per acre. Even at high water levels, the tundra vegetation tends to act as a boom and vegetation and peat as a sorbent, allowing water to filter through, trapping the more viscous oil (Barsdate et al. 1980) and also making recovery of the oil more difficult. On the other hand, even small spills can spread over large areas, if the spill event includes aerial, pressured discharge. For example, in December 1993, an ARCO Drill Site line failed and 1 to 4 barrels of crude oil misted over an estimated 100 to 145 acres (Ott 1997). For a large spill during breakup conditions or the summer season, oil-spill response likely would recover the bulk of spilled oil. However, sufficient oil could remain to result in lethal and sublethal toxicity levels in waters within the spill area for approximately 7 years. In addition, equipment used to contain and recover spilled oil could damage the tundra surface, potentially leading to thermokarst erosion and causing local water quality degradation.

4.12.4.5 Vegetation

The only reported blowout of crude oil on Alaska's North Slope occurred in 1950 (Fairweather E&P Services, Inc. 2000), and no crude oil was spilled off the pad during that blowout. There is no history of the effects of a very large spill of crude oil on North Slope tundra vegetation. Overall, past spills (of much smaller volumes) on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown good potential for recovery, with wetter areas recovering more quickly (Jorgenson 1997, McKendrick 2000, National Research Council 2003). It is estimated that a spill of 120,000 barrels would cover up to 79,000 acres (at the highest gas/oil ratio and worse case winds), with 80 percent of the oil falling out on less than 935 acres. It is assumed that most of the vegetation within that area would be impacted to some degree. A portion of the vegetation affected would likely suffer longer-term consequences, meaning that recovery would take longer and might not be as complete. If a large oil spill were to occur during winter when the ground surface is frozen and covered with snow and ice, cleanup of the oil would be more complete (i.e., a greater proportion of it recovered) and impacts to the vegetation would be less than if a spill were to occur in the summer. In the latter case, not only would a higher proportion of the oil be likely to soak into the ground, causing greater and more persistent impacts, but also the trampling and compacting effects of clean-up activities on the unfrozen ground would cause additional impacts to vegetation.

4.12.4.6 Wetlands and Floodplains

There is no history of the effects of a very large spill of crude oil on North Slope wetlands. Past spills (of much smaller volumes) on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown good potential for recovery, with wetter areas recovering more quickly (Jorgenson 1997, McKendrick 2000, National Research Council 2003). It is estimated that a spill of 120,000 barrels would cover up to 79,000 acres with 80 percent of the oil falling out on less than 935 acres. It is assumed that most of the vegetation within that area would be impacted to some degree. A portion of the vegetation affected would likely suffer longer-term consequences, meaning that recovery would take longer and might not be as complete.

A very large crude-oil spill within the floodplain could have serious impacts to streams. The petroleum residue from a spill could be flushed from most streams within a few years. Additionally, a very large spill could saturate the tundra mat with oil, limiting the amount of crude oil that was recovered, and considerably lengthening the time over which impacts could occur. A spill that occurred in the winter could have similar impacts, although the snow and cold temperatures would retard the crude-oil runoff into the watershed as the snow soaked up the oil and limited the contamination. A spill that occurred during spring break-up or fall freeze-up could have the greatest impacts, since it would be extremely difficult, if not impossible, to contain the spill when ice was either breaking apart or forming into semi-solid slush pans or jumble ice. Spill cleanup in the watershed would involve containing the spill, diverting or isolating it within the water body, skimming off the oil, and treating the remaining oil-contaminated water and sediments. Prevention and rapid response with adequate removal equipment would minimize effects.

4.12.4.7 Fish

As discussed in section 4.3.7.2 (Volume 2), oil spills have been observed to have a range of effects on fish, depending on the concentration of petroleum present, the length of exposure, and the stage of fish development. The types of effects on fish from a very large oil spill would be the same as those described for relatively small oil spills. However, the magnitude of effects would be expected to be exponentially greater due to the increased concentration of oil, the longer exposure period, and the greater geographic extent of the spill. Assuming that a very large spill would reach aquatic habitat sustaining abundant fish resources, the timing of the spill would be the primary factor influencing the susceptibility of fish to impacts.

A spill during winter would have the least potential effects on fish under the assumption in section 4.12.3.1 that oil would remain above the ice. In such a case, the success of clean-up efforts is expected to be high in freshwater and nearshore marine areas. Since contaminated snow and ice can be physically removed, only residual levels of oil should remain and effects on fish would be minimal.

During spring thaw, broken ice conditions would occur in lakes and streams and along the coastline. The dispersion of oil among ice floes would inhibit initial clean-up efforts, but the subsequent flooding and peak stream flows associated with this time period would help flush spilled oil out of many freshwater habitats, reducing the ultimate impact on freshwater fish. On the other hand, oil would likely concentrate in coastal areas, placing nearshore marine and anadromous fish at greatest risk. Larvae and juvenile fish that are transported by currents and wind would not be able to avoid contaminated areas as well as adult fish and would be the life stages most vulnerable to effects.

If a spill occurred during summer, oil would be transported down streams at a relatively slow rate, as base flows are significantly lower than spring peak flows. As a result, a portion of the oil would be likely to persist in lateral habitats and sink in slow water reaches, resulting in major effects on freshwater fish. Similarly, if the spill entered a lake, the extensive residence time of the oil would lead to substantial effects on fish. As oil reached coastal waters, the ability to contain the spill would be fairly effective due to the ability to freely maneuver watercraft and place booms. While this would concentrate the spill in a smaller area and potentially worsen localized effects on nearshore marine or anadromous fish, it would reduce the geographical extent of impacts. Many fish would also have the opportunity to move laterally along the coastline and avoid the affected area.

A very large oil spill into broken ice during fall freeze-up would make clean-up efforts difficult to impossible, meaning much of the oil would remain in the aquatic environment until the following open-water season. While some of the oil would freeze into the ice layers, oil would also enter liquid water interspersed among the broken ice. The presence of oil in stream or lake overwintering habitat could cause additional physiological stress on freshwater and anadromous fish at the time when metabolic demands are greatest. Much of the oil could end up in the downstream reaches of rivers and impact deltas that are used extensively by fish for overwintering. The nearshore coastal zone freezes to the bottom in winter, so oil would be bound in ice there and released into the water during the following spring. At that time, large volumes of water flushing out of major rivers could potentially push some of the oil further into the Beaufort Sea or Chukchi Sea and effect marine fish.

A very large oil spill occurring at any time other than winter would likely lead to population level effects on some fish species, assuming that the winter dispersion of oil would remain on top of ice in a manner that would facilitate removal prior to spring breakup. The location of a very large spill relative to fish species distribution would ultimately determine which species are the most susceptible to these population level effects. However, for spills in the NPR-A the freshwater and anadromous fish (Table 3–18 in Volume 1) would be the most likely to experience those effects. The Exxon Valdez oil spill in 1989 was in excess of 250,000 barrels (Rice et al. 1996), a very large spill based on the definition utilized for this analysis. In that case, intertidal fish had reduced density and biomass within one year after the spill (Barber et al. 1995). Additionally, while it was initially assumed that population-level impacts on any fish species were almost exclusively from acute mortality, delayed population reductions resulted from the unforeseen persistence of subsurface oil and sublethal effects (Peterson et al. 2003). For example, two nearshore fish species still showed evidence of hydrocarbon exposure in primary and peripheral spill areas 10 years afterwards (Jewett et al. 2000). One factor related to this could be the fact that weathered crude oil can cause sublethal effects and mortality in eggs and larvae at a lower observed effective concentration than less-weathered oil, which has a lower proportion of high molecular weight polynuclear aromatic hydrocarbons (Carls et al. 1999). The spatial extent of impacts from that very large oil spill was also vast, with some fish having indications of exposure nearly 400 miles from the spill site in the year following (Collier et al. 1996).

4.12.4.8 Birds

Vulnerability of bird populations to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of a spill also is variable. Because they are unable to fly, molting birds probably are the most vulnerable to an oil spill. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, and feeding). Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution. Species dependent on widely dispersed prey would have more limited effects. In addition, nonbreeding individuals and those that have completed annual parental activities are better able to search for prey in uncontaminated areas. However, those individuals actively feeding young and dependent upon nearby food resources would be unable to seek uncontaminated prey elsewhere. If losses are substantial in a species with a low reproductive rate recovery may take many years, or populations may not recover to their pre-spill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate.

A spill during winter would have the least potential effects on birds under the assumption that the oil would remain above the ice and would not enter open water. In such a case, the success of clean-up efforts is expected to be high. Since contaminated snow and ice can be physically removed, only residual levels of oil should remain. During winter all blowout spill locations would cause equal and very minimal impacts to birds as there are few birds present in the NPR-A in the winter and oil should be cleaned up prior to the arrival of spring migrants.

During spring thaw, ice and snow conditions are variable and as thaw proceeds ice and snow concentrations decrease and any oil located on water will behave as an open-water spill. Broken ice conditions would occur in lakes and streams and along the coastline. The dispersion of oil among ice floes would inhibit initial clean-up efforts, but the subsequent flooding and peak stream flows associated with this time period would flush spilled oil out of many freshwater habitats, concentrating oil concentrate in coastal areas and ice leads. In addition, it is unlikely that all of the spilled oil would be removed from the environment. During spring migration, substantial numbers of migrants moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives until open water off river deltas is available as the ice breaks up in late spring. The most numerous species include king eider, common eider, long-tailed duck, brant, and murres. Likewise, a similar restricted open water situation exists in both the Beaufort and Chukchi seas for migrants that pause awaiting further melting to the north or east, and for birds occupying delta waters and nearshore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats. Thus, a blowout spill during spring thaw occurring in a location that would allow significant amounts of spilled oil to reach near and offshore marine areas during the spring migration period would be the most damaging situation for birds and could cause population level consequences to some bird species.

A blowout spill occurring during summer would have the greatest negative effect on birds if it took place in a location where large amounts of spilled oil could be transported via waterways to large lakes and coastal nesting, molting and brood rearing areas. If the spill entered a lake, which contained large numbers of breeding or molting birds, the extensive residence time of the oil would lead to substantial effects on those birds. Many brood rearing females and their young use waterways to move among lakes and to make their way to the coast prior to fledging. Oil in these waterways could impact significant numbers of birds and could have significant impact to the breeding success of some species for that year. Individuals undergoing wing molt or post molt staging often congregate in large flocks at coastal locations and large numbers of birds would be susceptible to oil if it reached the nearshore marine environment.

A blowout spill that occurred during fall freeze-up would have the greatest negative effects on birds if it took place in a location that would allow significant amounts of spilled oil to reach near and offshore marine areas. A very large oil spill getting into broken ice during fall freeze-up would make clean-up efforts difficult to impossible; meaning much of the oil would remain in the aquatic environment until the following open-water season. The nearshore coastal zone freezes to the bottom in winter, so oil would be bound in ice there and released into the water during the following spring. At that time, large volumes of water flushing out of major rivers could potentially push some of the oil further into the Beaufort or Chukchi sea and effect birds of many species as detailed in the above section on spring thaw. This scenario assumes that most of the birds would have departed both the onshore and offshore areas of the NPR-A prior to the spill occurring. A spill of this type during fall freeze-up could cause population level consequences for some bird species.

4.12.4.9 Terrestrial Mammals

Impacts to terrestrial mammals from a very large oil spill could have widely varying impacts depending upon the time of year and the habitat types affected (i.e., some habitats are used more, or differently, than others). A spill that occurred in winter would generally have less impact on terrestrial mammals as some species (e.g., caribou) are less concentrated at that time. More importantly, cleanup of a winter spill would be more complete due to frozen ground conditions and less mammal habitat would be adversely affected. In contrast, a blowout during the peak of the mosquito season within the TCH caribou insect-relief area north and east of Teshekpuk Lake (i.e., an area with a high concentration of caribou, might cause the greatest impact to that species). Any terrestrial mammals in the immediate vicinity of the blowout could be contacted by oil falling onto the surrounding tundra and open water. Loss of thermoregulation would not be a factor, except possibly in young caribou calves. Mobile animals such as caribou, bears, and moose would likely move out of the area affected by the blowout, reducing their exposure. Some animals could be killed from exposure to toxins, either absorbed through the skin or ingested during feeding. Ingestion typically results in pulmonary aspiration that can be lethal or predispose the animal to infections. Terrestrial mammals would be temporarily disturbed or displaced by cleanup and site rehabilitation activities. At this time of year, Teshekpuk Caribou Herd caribou would be aggregated into large groups for insect avoidance. If a blowout occurred in the vicinity of an aggregation, a relatively large number (hundreds to several thousands) of caribou could be exposed to oil fallout. Movement of insect-harassed caribou in the vicinity of the blowout could be disrupted during the duration of the blowout and the following period of cleanup, reducing caribou foraging efficiency. If foraging efficiency was reduced enough to result in reduced weight gain, there could be greater over-winter mortality or a corresponding reduction in offspring produced the following year. This effect would only last for one season and would not result in long-term reduction in the population size unless followed or preceded by a few years of higher mortality or lower birth rates from other factors. The amount of habitat affected by such a spill would be minimal when compared to the amount of caribou habitat available on the North Slope.

4.12.4.10 Marine Mammals

The low-probability of a very large oil spill makes it unlikely that marine mammals would be negatively impacted by such an event. If however, a large oil spill did occur in the marine environment, impacts to marine mammals could be dramatic and long lasting. After the Exxon Valdez Oil Spill in 1989, high numbers of marine mammals were found dead or sick from exposure to spilled oil throughout Prince William Sound. Prey resources were also heavily impacted and in some cases, such as Pacific herring, have yet to recover (Exxon 2010). Oil spill response capabilities in the arctic marine environment are currently even more limited than what was available for the Exxon Valdez Oil Spill (Pew 2011) making adequate response unlikely. Effects from such a spill could be compounded by effects due to climate change.

For marine mammals to come in contact with produced oil from a very large oil spill would require that the spill occur in saltwater (which is unlikely due to the very limited coastal waters in the NPR-A and their close proximity to the shore; there would be no benefit to actually drilling in these areas because of the expense of design requirements when any potential petroleum could be reached more efficiently from an onshore directional drilling approach) or that it enter a major river system near the coast during the broken ice period. During other periods, cleanup and containment would be expected to prevent most produced fluids from entering the marine environment. Therefore, the likelihood of a spill impacting marine mammals is dependent not only on the location of the spill but the season.

Winter

The area immediately off shore of the planning area is covered by land-fast ice during winter. Any spilled fluids would remain on the top of the ice and the success of clean-up efforts is expected to be high. No marine mammals with the exception of polar bear (see section 4.12.4.11) would be present so the only threat would be from oil not cleaned up that enters the marine system during break-up. The amount of oil would likely be very low and unlikely to have significant effects on marine mammals.

Broken Ice (Fall Freezeup and Spring Breakup)

During these periods clean-up and containment success is comprised by environmental conditions. Spilled fluid reaching the marine environment would generally be contained within the ice. In the case of a fall spill, it is expected that most fluid would be frozen within the ice and released during summer melt. This could affect marine mammals using the near shore environment either through direct contact or impacts to prey species. The number of animals affected would be dependent on the aerial extent of the spill and its location as well as the animals' behavior. Animals that typically occur in groups (beluga whales) may have more individuals affected, but may have a relatively lower overall chance of coming into contact with a spill because they are not evenly distributed. Actual numbers and movement rates would also influence the number impacted. Active clean-up efforts during the melt may cause some animals to avoid the area reducing the chance of contact.

A spill during spring-break-up that reached the lead system or became trapped under ice could impact relatively more animals because the oil may become concentrated (constrained by the ice) in the open water where migrating and foraging marine mammals are also concentrated – increasing the potential for contact and subsequent injury and mortality.

Summer

If a very large oil spill occurred along the shore during the summer open-water season or was transported via a river to the marine system, the spill would contaminate marine waters although containment efforts are expected to be successful during this season. Small numbers of spotted seals could be exposed to the spill. Smaller numbers of other marine mammals, such as ringed and bearded seals, and beluga whales that generally occur offshore during the summer, could be exposed to oil if the spill were to spread offshore. If spotted seals were to be oiled and suffer lethal effects from the spill, the small population could take a few years or more to recover. Losses of other marine mammals to the spill would likely be small, with recovery of populations expected within one generation.

4.12.4.11 Special Status Species

Special Status Species of Plants

The only reported blowout of crude oil on Alaska's North Slope occurred in 1950 (Fairweather E&P Services, Inc. 2000), and no crude oil was spilled off the pad during that blowout. There is no history of the effects of a very large spill of crude oil on North Slope tundra vegetation. Overall, past spills (of much smaller volumes) on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown good potential for recovery, with wetter areas recovering more quickly (Jorgenson 1997, McKendrick 2000, National Research Council2003).

Populations of sensitive plants can be avoided during development, but if a population occurs within 6 miles (33,000 feet) of a well pad experiencing a blowout, individuals of that population may become oiled. There would be a higher probability of plant death within 3,600 feet of the well (area receiving 80 percent of the oil fallout) compared to plants occurring between 3,600 and 33,000 feet of the well. If a large oil spill were to occur during winter when the ground surface is frozen and covered with snow and ice, cleanup of the oil would be more complete (i.e., a greater proportion of it recovered) and impacts to sensitive plant species would be less than if a spill were to occur in the summer. In the latter case, not only would a higher proportion of the oil be likely to soak into the ground, causing greater and more persistent impacts, but also the trampling and compacting effects of clean-up activities on the unfrozen ground would cause additional impacts to plants.

Special Status Species of Birds

Vulnerability of special status species populations (particularly spectacled and Steller's eiders and yellow-billed loons) to an oil spill is highly variable because of their seasonally patchy distribution in areas where the probability of a spill also is variable. Because they are unable to fly, molting birds probably are the most vulnerable to an oil spill. For all species, the degree of impact depends heavily on the location of the spill and its timing with respect to critical natural behaviors (e.g., breeding, molting, and feeding). Oil contamination of food resources may influence recovery of a local population by affecting reproductive success and survival, with the degree of impact largely dependent on the patterns of prey distribution. Species dependent on widely dispersed prey would have more limited effects. In addition, nonbreeding individuals and those that have completed annual parental activities are better able to search for prey in uncontaminated areas. However, those individuals actively feeding young and dependent upon nearby food resources would be unable to seek uncontaminated prey elsewhere. If losses are substantial in a species with a low reproductive rate recovery may take many years, or populations may not recover to their pre-spill size. Rate of recovery from oil spill mortality depends both on the numbers lost from a particular species population and its prevailing population trend, which in turn are determined by reproductive rate and survival rate.

A spill during winter would have the least potential effects on special status species under the assumption that the oil would remain above the ice and would not enter open water. In such a case, the success of clean-up efforts is expected to be high. Since contaminated snow and ice can be physically removed, only residual levels of oil should remain. During winter all blowout spill locations would cause equal and very minimal impacts to special status species as they are not present in the NPR-A in the winter and oil should be cleaned up prior to the arrival of spring migrants.

During spring thaw, ice and snow conditions are variable and as thaw proceeds ice and snow concentrations decrease and any oil located on water will behave as an open-water spill. Broken ice conditions would occur in lakes and streams and along the coastline. The dispersion of oil among ice floes would inhibit initial cleanup efforts, but the subsequent flooding and peak stream flows associated with this time period would flush spilled oil out of many freshwater habitats concentrating oil concentrate in coastal areas and leads. In addition, it is unlikely that all of the spilled oil would be removed from the environment. During spring migration, substantial numbers of yellow-billed loons, spectacled and Steller's eiders moving north along the spring lead system in the Chukchi Sea are at risk if oil enters this habitat, since there are few alternatives until open water off river deltas is available as the ice breaks up in late spring. A similar restricted open water situation exists in both the Beaufort and Chukchi seas for migrants that pause awaiting further melting to the north or east, and for birds occupying delta waters and nearshore areas that have melted prior to general ice breakup and awaiting the availability of onshore habitats. Thus, a blowout spill during spring thaw occurring in a location that would allow significant amounts of spilled oil to reach near and offshore marine areas during the spring migration period would be the most damaging situation for yellow-billed loons, spectacled and Steller's eiders and could cause population level consequences to these species.

A blowout spill occurring during summer would have the greatest negative effect on birds if it took place in a location where large amounts of spilled oil could be transported via waterways to large lakes and coastal nesting, molting and brood rearing areas. If the spill entered a lake which contained large numbers of breeding or molting birds (particularly spectacled and Steller's eiders and yellow-billed loons), the extensive residence time of the oil would lead to substantial effects to those birds. Many brood rearing female spectacled and Steller's eiders and their young use waterways to move among lakes and to make their way to the coast prior to fledging. Oil in these waterways could impact significant numbers of these birds and could have significant impact to the breeding success of those species for that year. Individuals undergoing wing molt or post molt staging often congregate in large flocks at coastal locations and large numbers of yellow-billed loons, spectacled and Steller's eiders would be susceptible to oil if it reached the nearshore marine environment.

A blowout spill that occurred during fall freeze-up would have the greatest negative effects on special status species if it took place in a location that would allow significant amounts of spilled oil to reach near and offshore marine areas. A very large oil spill getting into broken ice during fall freeze-up would make clean-up efforts difficult to impossible; meaning much of the oil would remain in the aquatic environment until the following open-water season. The nearshore coastal zone freezes to the bottom in winter, so oil would be bound in ice there and released into the water during the following spring. At that time, large volumes of water flushing out of major rivers could potentially push some of the oil further into the Beaufort or Chukchi Sea and effect birds as detailed in the above section on spring thaw. This scenario assumes that most of the populations of special status species would have departed both the onshore and offshore areas of the NPR-A prior to the spill occurring. A spill of this type during fall freeze-up could cause population level consequences for some special status species.

Special Status Species of Terrestrial Mammals

Despite predevelopment surveys for and subsequent avoidance of any discovered habitat of the Alaska hare and Alaska tiny shrew, it is possible that an oil or gas development or major oil pipeline could be constructed near a population of one or both of these species. If a large oil spill were to occur, its effects could spread beyond the facility and into hare or shrew habitat. Impacts from a very large oil spill may differ depending upon the time of year. Generally, a spill that occurred in winter would have less impact because the ground would be frozen and cleanup would be more complete, resulting in less habitat being adversely affected. For the Alaska tiny shrew, however, the trampling by vehicles and foot traffic during cleanup may kill as many shrews as the oil itself, either directly by crushing or through hypothermia once the insulating quality of the snow is removed. Potential spill effects to shrews include mortality of individuals, physiological stresses in surviving individuals, and possibly reduced breeding success if resulting low population density decreases the odds of finding a suitable mate. The result could be an adverse population level effect, but given the low probability of the spill, multiplied by the low probability of occurring near a rare species, the resulting probability of this population level effect is likely negligible.

Special Status Species of Marine Mammals

If oil from a spill or blowout reached the marine environment, impacts to Special Status marine mammals could be dramatic and long lasting. After the Exxon Valdez Oil Spill in 1989, high numbers of marine mammals were found dead or sick from exposure to spilled oil throughout Prince William Sound. Prey resources were also heavily impacted and in some cases, such as Pacific herring, have yet to recover (Exxon 2010). Oil spill response capabilities in the arctic marine environment are currently even more limited than what was available for the Exxon Valdez Oil Spill (Heiman 2011) making adequate response unlikely. Ringed and bearded seals are projected to decrease in population size due to changes in sea ice condition. Should species numbers decline to minimal numbers, individual loss of animals to these populations from an oil spill would be highly detrimental.

If a very large oil spill were to occur in an area along the northern coast of the NPR-A or along a river tributary to the Beaufort Sea, oil could enter the nearshore marine environment and potentially be transported to offshore areas. As with other marine mammals, the season during which a spill occurred would influence the potential impact, during winter bowhead whales are not present and the nearshore area is usually inaccessible due to land-fast ice. Onshore cleanup and containment would be expected to be successful and any remnant oil would likely have only a negligible impact. Only a saltwater release, such as in Dease Inlet, is expected to have the potential to reach the offshore areas bowheads frequent.

Under most circumstances, contact with whales migrating through offshore waters during the open-water season would be brief. In some years, however, bowhead whales have been observed very near shore between Point Barrow and Cape Halkett during the westward fall migration. For example, 77 individuals were observed feeding near the shoreline between Smith Bay and Dease Inlet in September 2000 (Treacy 2002a). If bowhead whales were feeding in an area when spilled oil was present, contact could be prolonged and some of the oil could be ingested. It is not known whether a brief exposure, especially of volatile components, would have effects on lung or eye function. A late fall spill could become entrained in the pack ice and the oil could be released into leads when the ice melted. However, a winter spill would likely melt out in July, so it is not likely that oil would be melted out of the ice in time to contact spring leads during the whale migration that spring (April and May) but could affect whales during summer and fall (dependent on detection and cleanup success) and prey.

During their spring migration, bowhead whales often are concentrated in the spring lead system as they move through the Chukchi Sea, past Point Barrow, and eastward through the Beaufort Sea. This behavior makes them extremely vulnerable to any oil entering the spring lead system. Once oil enters the lead system it would be somewhat contained and occur at higher concentrations than an open water spill. This potentially increases the chance of contact and the number of whales contacted. The relative increased concentration could also increase the likelihood of severe injury and subsequent mortality. Oil released in broken ice conditions would be more difficult to clean up and more likely to enter the spring lead system.

If a very large oil spill occurred along the shore during the summer open-water season or was transported via a river to the marine system, the spill would contaminate marine waters although containment efforts are expected to be successful during this season and spread would be limited. An early summer or late summer spill would have the most potential to impact bowheads. Spills during other time periods would likely exert a greater impact on prey species in the near shore environment.

Effects of an oil spill on bowhead whales would include oiling of the skin, inhalation of hydrocarbon vapors or oil, ingestion oil or contaminated prey, fouling of the baleen, reduction of food supply, displacement from feeding areas, and possibly death. The effect of fouling baleen has not been investigated adequately; the long filamentous bowhead whale baleen may be prone to more serious fouling than the coarser baleen of some other species, thereby depriving bowhead whales of a greater degree of normal function. The number of whales contacting spilled oil would depend on the timing and duration of the spill, ice conditions, effectiveness of containment and clean-up operations, and the whales' ability or inclination to avoid contact. Based on conclusions from studies that have examined the effects of oil spills on cetaceans, external exposure to spilled oil is unlikely to have serious effects on bowhead whales. Most whales exposed to small quantities of spilled oil would likely experience temporary, nonlethal effects, although lethal effects to some individuals could occur. Heavy exposure to spilled oil would likely have serious health and/or lethal effects to bowhead whales.

In the event of a large or very large oil spill, polar bears may avoid large portions of coastal habitat fouled by oil or be displaced from these areas by response activities. Avoidance or displacement may impact body condition, breeding success, or survival of individuals if they are excluded from feeding, resting, or denning areas for a prolonged period of time. Polar bears may also be directly oiled or ingest oiled prey items. Effects experienced by oiled bears may include mortality of individuals and sublethal physiological effects in surviving bears, which could reduce health and reproductive success. Under some scenarios, a very large oil spill could result in population-level effects or long-term impacts to the food chain.

In the event of a large or very large oil spill, walrus may be displaced from large portions of coastal habitat fouled by oil or be disturbed at haulout locations by response activities. Displacement and disturbance may impact body condition, breeding success, or survival of individuals if they are excluded from feeding and resting areas for a prolonged period of time. Walrus may also be directly oiled or ingest oil or oiled prey items. Effects experienced by oiled walrus may include mortality of individuals and sublethal physiological effects in surviving individuals, which could reduce health and reproductive success. Under some scenarios, a very large oil spill could result in population-level effects or long-term impacts to the food chain.

4.12.4.12 Cultural Resources

Because cultural resources in the NPR-A are located at or near the ground surface, a spill that occurred during the summer would have a greater effect on these resources than a spill that occurred during the winter. Oil spilled during winter, however, could impact cultural resources if the warm oil melted the snow and permafrost and impacted the underlying cultural resources. While the contamination of the cultural resources would render some of the data recovery valueless, the clean-up procedures would create even greater impacts. Since cultural resources are nonrenewable, the effects could result in loss of site integrity.

4.12.4.13 Subsistence

Spilled oil would have different impacts depending on the location of the spill. It is unlikely that resident fish in lakes and rivers would be affected by a marine spill and a contained land-based spill could be segregated from large mammals. Effects on subsistence-harvest patterns from a very large (120,000-barrel) oil spill on land could potentially displace and cause a functional loss of habitat to Central Arctic Herd, Teshekpuk Caribou Herd, and Western Arctic Herd caribou. Effects to subsistence would occur as this important subsistence resource became unavailable or undesirable for use, or experienced long-term (more than 5 years) population and productivity effects. Exposure of bowhead whales to spilled oil could result in lethal effects to some individuals, injury to many more, and long-term contamination of the fatty tissues and possible chronic ill health for many of the whales exposed to the spill. Large numbers of spotted seals could be exposed to the spill and suffer losses, with population recovery taking several years, and hunters decreasing harvests of subsistence resources for many years due to contamination. Losses of other marine mammals should be smaller, with recovery occurring within 1 year.

If a large spill were to occur when large concentrations of molting, staging, or migrating birds were present, tens of thousands of birds could be contacted by oil, representing a loss to regional populations and affecting subsistence and sports uses in the Y-K Delta as well as locations along the Pacific Flyway. A substantial number of resident and anadromous fish could be injured or killed by a very large oil spill, and other populations could be harmed by exposure to crude oil, suffer sub lethal effects and be considered contaminated. Access to subsistence hunting areas and subsistence resources and the use of subsistence resources could change if an oil spill reduced the availability of resources or altered their distribution patterns. Extra-regional efforts to acquire subsistence foods would be undertaken, possibly taxing the resources of other subsistence regions.

The communities of Anaktuvuk Pass, Atqasuk, Barrow, Wainwright, Point Lay and Nuiqsut could be affected by a very large oil spill in the planning area. Even if few individual subsistence species were directly lost or displaced, a very large oil spill could potentially contaminate essential nearshore whaling areas and onshore terrestrial hunting and fishing areas, causing effects when the additive impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together.

4.12.4.14 Sociocultural Systems

Sociocultural systems in the communities of Anaktuvuk Pass, Atqasuk, Barrow, Wainwright, Point Lay, and Nuiqsut could undergo long-term individual, social, and institutional stress and disruption from a 120,000-barrel spill. It is expected that considerable stress and anxiety would occur over the loss of subsistence resources, contamination of habitat and subsistence resources, fear of the health effects of eating contaminated wild foods, fear of changes to harvest regulations (e.g., quotas), and the need to depend on the knowledge of others about environmental contamination (Fall 1992, McMullen 1993). Individuals and communities would be increasingly stressed during the time it would take to modify subsistence-harvest patterns by selectively changing harvest areas (if such areas were even available) and there would be increased costs and risks associated with travel and hunting in unfamiliar areas. Associated cultural activities, such as the organization of subsistence activities among kinship groups and the relationships among those who customarily process and share subsistence harvests, would also be modified or would decline.

A 120,000-barrel spill would be expected to affect individuals and social systems in ways similar to the effects of the Exxon Valdez oil spill. Critical subsistence resources were contaminated. In the smaller communities, clean-up work produced a redistribution of resources, creating new schisms in the community and increasing social stresses. Many members of small communities who were on the road to sobriety before the spill began drinking again after the spill, leading to the reemergence of numerous alcohol-related problems (such as child abuse, domestic violence, and accidents). Institutional effects included additional burdens on local governments, disruption of existing community plans and programs, strain on local officials, difficulty dealing with Exxon, community conflict, disruptions of customary habits and patterns of behavior, emotional effects, and stress-related disorders from confronting environmental degradation and death, and violation of community values (Endter-Wada 1992). Post-spill stress resulted from the seeming loss of control over individual and institutional environments, as well as from secondary episodes such as litigation, which produced secrecy over information, uncertainty over outcomes, and community segmentation (Smythe 1990). Attempts to mitigate social effects were often ineffective because of concerns over litigation, causing a reluctance to intervene out of fear that these actions might benefit adversaries in legal battles (Impact Assessment, Inc. 1990b, 1998; Human Relations Area Files, Inc. 1994; Alaska Department of Fish and Game 1995). In response to spill hazards, there has been a resurgence in traditional strategies for responding to resource shortages, which in traditional times, and following the spill, resulted in an increase in sharing, a renewal and strengthening of social connections with extended family members and friends, and a cooperative approach to subsistence activities within and between the most affected communities.

4.12.4.15 Environmental Justice

Iñupiat Eskimos, a recognized minority, are the predominant residents of the North Slope Borough, the area potentially most affected by NPR-A exploration and development. An oil spill could disproportionately affect Iñupiaq residents because they rely on subsistence foods and there could be cumulative effects to subsistence resources and harvest practices.

In the unlikely event that a large spill occurred and contaminated essential nearshore whaling areas and onshore terrestrial hunting and fishing areas, major environmental justice effects could occur, stemming from contamination of the shoreline, tainting concerns, clean-up disturbance, and disruption of subsistence practice. Oil-spill contamination and cleanup could potentially displace and cause a functional loss of habitat to Central Arctic Herd, Teshekpuk Caribou Herd, and Western Arctic Herd caribou, as well. Such impacts would cause damage to subsistence resources, which would result in disproportionately high effects on the Iñupiat. Oil-spill contamination of subsistence foods, or the fear, stress and anxiety caused by the threat of such contamination, would be the main health-related concerns. Most potential effects to subsistence resources and subsistence harvests would be mitigated to some extent, though not eliminated.

4.12.4.16 Recreation Resources

The impacts to recreation resources from a very large oil spill would primarily relate to reductions in aesthetic values and naturalness associated with visible oil sheen and residues on vegetation and water. The effects on recreation opportunities would be short term in nature and would dissipate as cleanup and rehabilitation proceeded. Recreation resources would recover over time.

4.12.4.17 Wild and Scenic Rivers

A low-probability very large oil spill would impact eligible river values by direct impacts to water quality, and indirect impacts to recreation, subsistence and wildlife resources.

A spill during winter would have the least potential effects on river values under the assumption in section 4.12.3.1 that oil would remain above the ice. In such a case, the success of clean-up efforts is expected to be high in freshwater and nearshore marine areas. Since contaminated snow and ice can be physically removed, only residual levels of oil should remain and effects on river values would be minimal.

During spring, dispersion of oil among river ice floes would inhibit initial clean-up efforts, but the subsequent flooding and peak stream flows associated with this time period would help flush spilled oil from eligible rivers, reducing the ultimate impact to water quality. Impacts would probably be concentrated in lowland areas where velocities are relatively low, and these areas would generally be downstream of eligible river areas, which generally occur in steeper terrain.

If a spill occurred during summer, oil would be transported down streams at a relatively slow rate, as base flows are significantly lower than spring peak flows. As a result, a portion of the oil would be likely to persist and sink in slow water reaches, resulting in long-term recurring impacts to water quality.

A very large oil spill into broken ice during fall freeze-up would make clean-up efforts difficult to impossible, meaning much of the oil would remain in the aquatic environment until the following open-water season. While some of the oil would freeze into the ice layers, oil would also enter liquid water interspersed among the broken ice. At breakup, large volumes of water flushing out of major rivers could potentially push some of the oil further into the lower Colville River or Chukchi Sea.

4.12.4.18 Wilderness Characteristics

The impacts to wilderness characteristics from a very large oil spill would primarily relate to reductions in aesthetic values and naturalness associated with visible oil sheen and residues on vegetation and water. Effects on wilderness characteristics would depend on the care taken during the clean-up process. If the scars on the landscape from clean-up activities were effectively rehabilitated, the long-term effect on wilderness characteristics would be minor.

4.12.4.19 Visual Resources

A very large oil spill in the winter would have little effect as the spill would be absorbed in the snow and ice and removed prior to breakup. A very large oil spill during summer would impact visual resources by the visible oil and the resulting damage to the underlying vegetation. However, spills are most likely to occur on already disturbed areas such as drill pads and production areas and would not increase the area already visually impacted.

4.12.4.20 Economy

The economic ramifications of a very large oil spill vary from direct response to stop a well blow out, through clean up, to disrupted business activities and the loss of the use of other resources over an extended time. Initial response to control a blow out and prevent additional environmental damage may be performed with workers at related or nearby facilities with stockpiled spill response supplies and equipment, and have economic effects ranging from overtime and replacement or refurbishment of items used to financial compensation for distress, injury, or death. Extended response for a very large spill will require rapid mobilization of additional workers, supplies, and equipment from other areas within Alaska and outside Alaska. The resources actually used to clean up a possible 120,000-barrel oil spill would depend on the procedures that were called for in the oil-spill contingency plan, the level of preparedness (equipment and training) of the entities responsible for cleanup, the efficiency of the cleanup activities, and the degree of coordination between the numerous responsible entities.

Much of the equipment required for extended response would be acquired by contract or similar arrangement and result in significant expenditures. Equipment may include fixed and rotor wing aircraft, marine vessels (seasonally), land transportation (seasonally specific), temporary housing and catering facilities, skimmers, boomers, dozers, and other heavy equipment. Many necessary types of equipment may be available in and near Prudhoe Bay and used under shared response agreements within industry. Some equipment may be available in North Slope Borough communities, resulting in moderate to substantial increases to personal earnings in the Borough, possibly displacing other work. It is likely that recovery efforts would require support from Fairbanks, Anchorage, and other areas within Alaska, resulting in moderate to limited effects for those areas. Some equipment may be transported from areas outside Alaska, and result in negligible economic effects to the rest of the United States.

The estimate of spill-related employment used in this analysis for a very large spill of 120,000 barrels is based on the most relevant historical experience of a spill in Alaska, the Exxon Valdez oil spill of 1989, using the ratio of workers to barrels spilled. The Exxon Valdez spill was 240,000 barrels, and generated enormous employment that rose to the level of 10,000 workers doing direct cleanup work in relatively remote locations. Smaller numbers of clean-up workers returned in the warmer months of each subsequent year until 1992. The planning area spill scenario assumes the spill would occur on land, not near the Beaufort or Chukchi seas, and not on possible drainage systems near and leading to those seas so the number of workers could be significantly less than the proportional effort to clean up the Exxon Valdez spill. If the spill occurred on a drainage system near a sea, then the clean-up effort would likely be close to that required to clean up the Exxon Valdez spill. At the most intense requirement, an oil spill of 120,000 barrels is expected to generate approximately 5,000 jobs for 6 months in the first year, declining to zero by the third year following the spill. An unknown number of North Slope Borough residents would be hired for these temporary jobs, and workers would be transported from other communities within and outside Alaska. Given the need for rapid mobilization, it is expected that available workers closer to the incident would be more likely to be hired, so positions are more likely to be filled by North Slope Borough and Alaskan workers.

In the case of the Exxon Valdez spill, numerous local residents quit their jobs to work on the cleanup, often at substantially higher wages, which generated inflation in the local economy (Cohen 1993). Anecdotal information indicates that housing rents in Valdez in 1989 increased by 25 percent in some cases to 6-fold in others, and inflated rents continued into 1990. The North Slope Borough will not experience similar inflation effects because cleanup activities will be managed and staged out of existing enclave-support facilities. While it may not inflate residential lease values, the sudden diversion of transportation resources to spill response efforts may inflate non-spill transportation costs of people and goods to the villages.

It is likely that additional housing and support facilities would be required for the temporary workers. If the infrastructure is located onshore, it would be subject to state and local property tax. Depending on the season and other factors, cruise and other ships have provided housing for temporary workers, though not in the Chukchi or Beaufort Seas. Ships would not be subject to property taxes.

A very large spill could result in displacement of recreation and subsistence use. It is not expected to reduce recreational activity or increase the cost of participation, because most parties use chartered flights that can reach other locations for hunting or boating activities. Displacement of subsistence activities will increase the cost of travel to participate, and may increase reliance on processed foods purchased from outside NPR-A.

4.12.4.21 Public Health

The impact of a very large oil spill on air quality is described in detail in section 4.12.4.1. Potentially harmful emissions of several EPA criteria pollutants are likely to occur and could result in significant levels of nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), and volatile organic compounds (VOC). The impact is likely to be greatest following an initial blowout. Respiratory irritation, asthma and exacerbations of chronic obstructive lung disease are likely to increase in areas where concentrations of the pollutants are greatest. Pre-existing lung disease and prolonged exposure to respiratory irritants will be the greatest risk for exposed individuals.

The greatest and most persistent impacts to public health following a very large oil spill are likely to result from stress, anxiety, and changes to subsistence harvest patterns. Impacts on subsistence are described in detail in section 4.12.4.13 and are likely to result from a combination of factors including diversion of hunters to jobs in the spill response; contamination and perception of contamination of food sources; and displacement and/or mortality of subsistence animal stocks. The experience of the Exxon Valdez spill demonstrated that changes in consumption patterns may persist in some communities long after species themselves recover. Persistent changes in diet and nutrition are likely to result in increases in the rate of food insecurity and increased prevalence of diabetes and related chronic disease. To the degree to which contamination enters the food system, increases in cancer may occur.

In addition to the environmental impacts of a very large oil spill, the short-term strain from an influx of outside workers following an accident would result in a number of other health impacts. The presence of migratory workers in isolated areas is associated with the spread of infectious disease, particularly sexually transmitted infections (Goldenberg 2008). Rates of chlamydia, gonorrhea, and other sexually transmitted infections would be expected to increase after a very large oil spill as the population of extra-regional workers rises.

Similarly, the population increase in response to a very large oil spill may strain the already limited capacity of the local health care system, particularly if the response results in temporary settlement of workers in villages outside of Barrow or Deadhorse. Additional strain on the health care system may result from increased burden of disease, starting with potential respiratory illness in the immediate post-spill environment and persisting through changes in chronic disease and social pathology resulting from long-term alterations in subsistence activities and sociocultural systems.

Social pathology, including alcohol use and subsequent alcohol-related problems, is likely to occur following a very large oil spill as a result of stress, alterations in the social environment and support networks, and an influx of outsiders.

4.13 Energy Requirements and Conservation Potential of Various Alternatives and Mitigation Measures

There would be no unusual energy requirements for implementing any of the alternatives or their associated mitigation measures (including lease stipulations and required operating procedures). Generally speaking, energy requirements and conservation potential would be proportional to the amount of oil and gas activities conducted under each alternative.

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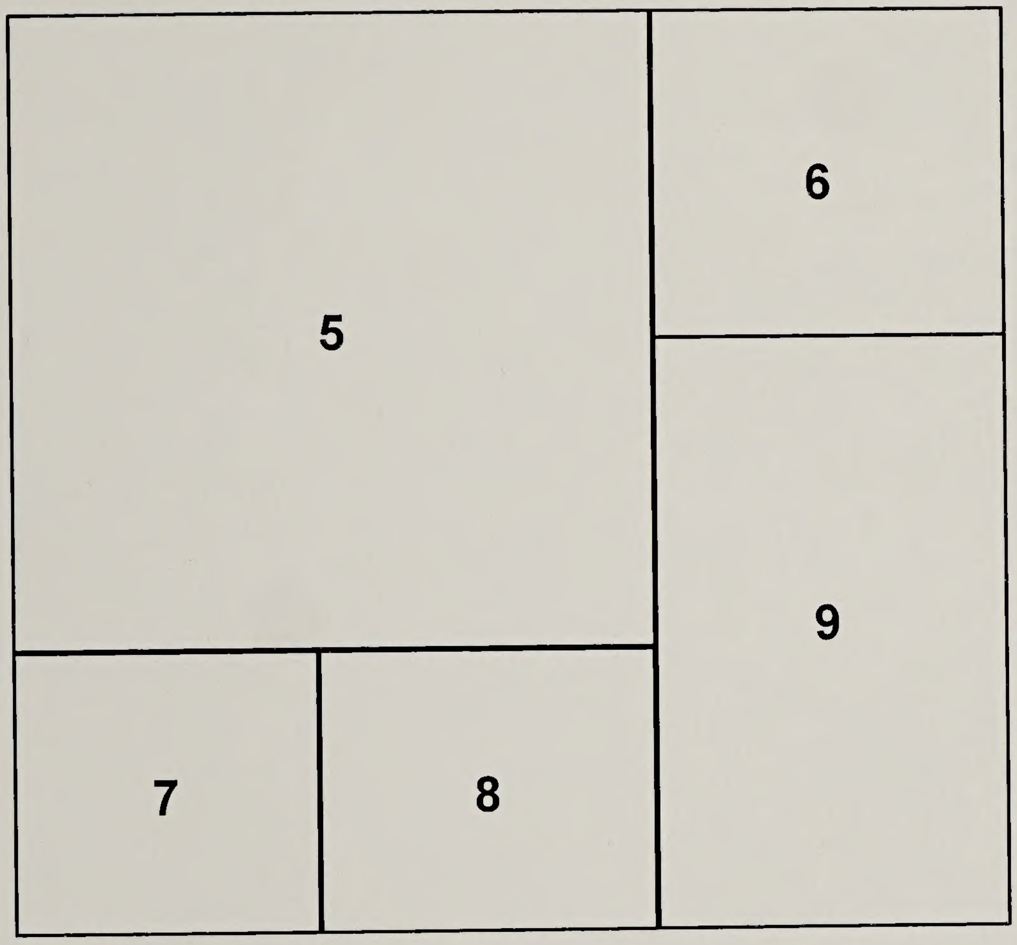

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6. Arctic Fox, National Petroleum Reserve-Alaska.

7. Transporting exploration drill rig equipment, National Petroleum Reserve-Alaska. Photo by NSSI.

8. Bear flowers on a thermokarst slump along the Colville River, National Petroleum Reserve-Alaska. © Richard Kahn

9. Subsistence ice fishing, Nuiqsut, Alaska. Photo by NSSI.